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PREFACE.

In collecting these papers for republication, most of them have been submitted to careful revision, and I believe they are all fairly on a level with the present state of knowledge.

The chapter on the use of alcohol is entirely new, and will be found, I think, one of the best practical expositions of the subject to be met with.

My own part in the volume has been small. But I am happy to have this opportunity of again returning my thanks to its authors, all of them eminent in their profession, for the kind way in which they responded to the requests for assistance in this work which were conveyed to them through me.

JAMES HINTON.

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PHYSIOLOGY FOR PRACTICAL USE.

I.

THE BRAIN AND ITS SERVANTS.

In the course of this volume we shall have a great deal to say about the Nerves; and as these are the means through which all our organs perform their part, it is perhaps, advisable, first of all, to devote a little space to them, and to the great centre of them all, the Brain.

The likeness of the brain and nerves to a telegraph, with its lines of wire, and the central office to which all lead and from which all depart, has been often noticed; and it has been supposed by some persons that these organs are really a kind of electric machine, in which currents are generated, and supplied wherever they are needed. But it is not truly so. The living body, indeed, like all things in which active changes are going on, is constantly pervaded by electricity; and in some animals (as the torpedo, or the electric eel) electricity is specially generated, in peculiar organs, to serve as the creature's offensive and defensive weapon. In these animals there are large nerves which serve to bring the electric organs into action at the right moment. But these organs are quite separate from and unlike the brain, and the currents which circulate in the nerves are of a more delicate and subtle kind. They are such as are generated in living beings alone, and can traverse no other substances than the nerves.

But still they are so much like electricity that we can best understand them by comparing the nerves with electric wires, and the living actions which produce nervous power with the means which set electric and galvanic currents in motion. And, first, the nerves are like electric wires in this, that impulses travel along them without any permanent change in themselves. In each case, there seems to be a sort of thrill passing from one end to the other, which may be best conceived by being likened to a motion transmitted along a row of balls lying in contact with one another. If the first of the series be sharply and yet gently struck, it passes on the impulse, without changing its own place, to the next, and that to the following one, and so on, until the last is reached, and it alone moves from its position. So, probably, it is with the minute particles which make up a wire when electricity passes along it; and somewhat in the same way, we may best conceive, it is with the minute particles which form the active portion of a nerve.

And again, as the impulse which starts a galvanic current is derived from chemical changes between an acid and a metal, from the union of the minute particles of these with one another, so the force which starts a thrill along a nerve comes, in all probability, from unions of minute particles in the brain, or around the other terminations of the nerves—in the ear, the eye, the skin. And if we are content (as in respect to subjects such as these we are obliged to be content at present, though we daily strive to make our knowledge more complete and truthful) with general thoughts, and keep always in mind how very imperfect all such views must be, it is not difficult to understand how the Creator has endowed us with so wonderful and perfect an instrument for perceiving and for acting, as our nervous system is. For all over the living body minute particles are every moment changing their place, uniting with one another, and disuniting.

There is no life without such constant interaction of the elements of which the body consists. And thus in these minute actions we may well understand there is an ever-ready source of nerve-power. The nerves take up and turn to account, as it were, power that would otherwise be wasted. The wonder is, that amid the innumerable multitude of actions within and influences without, so perfect an order is maintained that there is no excess and no lack on any hand, and no confusion; every organ of sense making its own distinct report, and every muscle receiving its own exact supply.

It is no wonder that the organs destined to be the channels and centres of this incessant and widely interwoven activity should be (as we shall see they are) highly complicated, and elaborately interconnected, each part being placed in due subordination to the whole. Nor is it any wonder that an organization so delicately subtle, so open to impression, and yet needing an adjustment so exact, should be so often liable to disorder, especially if the laws of its healthy working are unknown or disregarded.

One of the most striking points about the nervous system is that it has two quite distinct and even opposite parts to play. On the one hand, it is a stimulator; it excites to their proper actions all the organs; on the other, it is a controller of action, and perpetually restrains activities that would otherwise come into play. Of this we have plenty of evidence in our own will, which operates through the nerves.

Not very much less often do we exert it to repress an action which tends to its own performance, than to perform one which requires our effort. How hard it often is to refrain from laughter, or from tears!—how impossible entirely to repress the manifestations of our feelings! We cannot but tremble when we are in fear; we cannot long stop our breath. And this twofold character pervades all the operations of the nervous system; its function everywhere is partly to excite and partly to control. For these two purposes there exist distinct sets of nerves, which, however, are but a portion of the many varieties of nerves found in the human body. There is a set of nerves, for example, which keeps the heart beating; another set which controls and regulates its action, and these, when too violently excited, bring it to a sudden stand. But one of the chief ways in which this control of activity through the nerves is exercised, is by means of a special set of nerves distributed to the blood-vessels in every part of the body, and through which the vessels are made to contract or expand, so increasing or reducing the power of any organ. All the operations of the body are carried on under control; its activity is a regulated activity. Hence its perfectness—its harmony with nature. And the lesson is not hard to read; that is truly natural which is strictly regulated. If we would recognise in the moral world the features of life, we must find it in passions spontaneously bending to the Creator's laws.

So, too, in the brain itself: its activities are balanced one against the other, and its harmonious action comes out of the operation of each in its turn under the regulating influence of a power operating in the contrary direction. But of this we may speak more by-and-by.

A general outline of the nervous system is presented in Fig. 1. It consists of three great divisions—the brain, the spinal cord, and the nerves.

Of these the brain is the instrument by which we feel and think, and put into action the dictates of our will. The spinal cord stands, as it were, between the brain and the rest of the body; through it most of the actions we perform unconsciously are done; and besides this, it receives impressions and transmits them to the brain on the one hand, and on the other, in its influence on the body, the brain acts through it. The nerves connect these central parts, the brain and cord, with all the other organs. We shall speak first of the nerves.

Fig. 2 represents two nerves uniting with one another as they continually do. It will be seen that each nerve consists of a bundle of fibres. These are in the larger trunks extremely numerous, about 3000 occupying an inch. Each of these fibres consists of three parts—an outer covering, a roll of a white material, and a small central darker substance. We shall have a good idea of them if we liken them, on a small scale, to a very

FIG. 1.

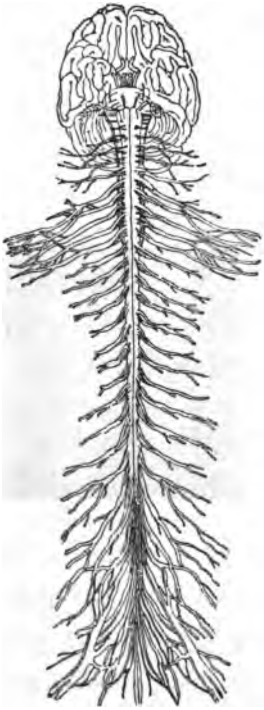
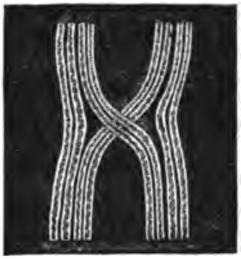


DIAGRAM OF THE NERVOUS SYSTEM.

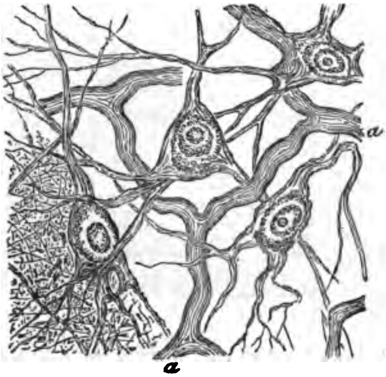
long wax taper rolled up in a piece of linen. The linen will be the external sheath, which is firm and strong, and serves as a protection; the wax will answer to the white material, and the wick may stand for the central substance. But this is not strong and fibrous: it is very fine and soft, and through it alone, we believe, the nervous currents pass. It seems, indeed, highly probable that this central substance answers strictly to the metallic wire in the electric cable, and that the white material, which does not reach to the extreme end of the nerve, answers the purpose of insulating the nervous current, being like the gutta-percha coating. If it be so, this is another striking instance of man's unconscious imitation of Nature. When we speak of a nerve, we mean a *bundle* of the nervous fibres described above, enclosed in a common sheath of membrane.

Fig. 2.



Among these wires of our nervous-telegraph, one set carry the messages inward to the spinal cord, and a different set convey outward the response. The first are the nerves of sensation, and pass chiefly to the skin; the latter the nerves of motion, and are given to the muscles. Besides these, there are another set of nerves, a little different in their form, which go to the small vessels, as before said, to make them contract or expand, in conformity with the condition of the nervous system. We see their action in the blush of modesty or the paleness of fear.

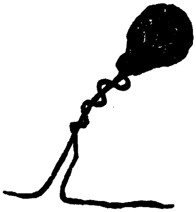
FIG. 3.



NERVE CELLS AND FIBRES.
a. A blood-vessel.

In all the organs of sense, these fibres end in special structures, adapted to receive each peculiar impression, as of sound, or light, or taste; in the muscles the inmost axis subdivides into still minuter twigs, which spread themselves over all the fibres, and thus bring every portion under the influence of the controlling will. At the centre, the nerves end in a different way. Here each nerve-fibre is connected with a peculiar rounded body termed a cell. These cells are exhibited in Figs. 3 and 4. Fig. 3 shows a small group of nerve-cells, with the nerve-fibres intermingled; and Fig. 4 represents a single cell with two nerve-fibres issuing from it; or, rather, as one must believe, with one issuing from it, one passing into it. Of the use of these cells something is known. The impression received through a nerve filament, say from the eye or ear, is in the cell "reflected," as it is said, into another nerve-fibre which conveys an influence to a muscle; as, for example, to the muscle which contracts the pupil, or adjusts the tension of the membrane of the

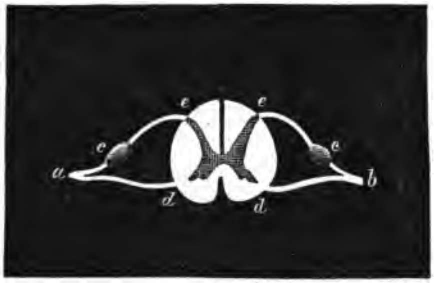
FIG. 4.



A NERVE-CELL WITH TWO FIBRES.

drum. This is the simplest form of nervous action, and in it the mind has no part. Thus are performed the actions which we do involuntarily, as breathing; or quite unconsciously, as winking. Thus, the heart beats and the stomach secretes the digestive fluid. These little cells are small storehouses of nervous force, which the impulses produced in the nerve-fibres by light, or sound, or touch, set free, and cause to flow along the nerve-fibres to any muscle with which the cell is connected.

FIG. 5.



SECTION OF THE SPINAL CORD.

a. b. Nerves. *c.* Ganglion of cells on the posterior root, which is the nerve of sensation. *d.* Origin of the motor root. *e.* Origin of the sensitive root. The dark part in the centre represents the cells of the cord.

Now the spinal cord (see Fig. 1) is made up of cells of this kind, with bundles of fibres round them, which fibres connect the cells and the nerves to each other, and all with the brain. Fig. 5 is a section of the cord, showing how the nerves come to it and pass off from it. Through the branch with the swelling on it (which is a small cluster of nerve-cells) the impressions are transmitted to the cells in the cord, and through the other branch the impulses pass outwards to the muscles. These two branches are called the *roots* of the nerve; they are soon united indistinguishably together, and separate again only at the other end of the nerve, where one set of fibres goes to the muscles, the other to the part that feels: the greatest number, by far, of all these fibres goes to the skin.

It is through the spinal cord, thus constructed, that almost all our involuntary actions are carried on. By the same means it is that insects will act, after their heads are removed, precisely as if they still felt and designed. Such actions are carried on by the nervous system, by virtue of its own structure and powers, with no mind in them. And it is well it is so. If our will were necessary to their performance, they would often be sadly neglected. How long should we keep on breathing if it required a special effort of ours for every breath? How long would it be before our heart stopped beating, if each pulse waited for our will to start it? At the very least we could never sleep; or, even if we could live on such conditions, what would our life be worth, consumed as it would be in the mere process of existing? Nothing in our whole structure is more wonderful or more beautiful than this office of the spinal cord, whereby all the constant processes of life are withdrawn from our concern, and carried on without our thought. Thus the nobler part of us is set free to attend to worthy objects, and the truly human life is erected, as on a pedestal, upon the animal life which serves it, and which should ever be held as its servant.

Of this higher life of thought and feeling the brain is the instrument. But though the office is different, the principle on which it is carried out is the same, and the same structures are made use of. Cells and fibres constitute the spinal cord; precisely similar cells and fibres constitute the brain. By impulses received from without through the fibres, and actions thus evoked in the various groups of cells, the lower functions of the body are maintained; by similar impulses, evoking corresponding actions in the brain-cells, the functions of the intellectual and moral life, so far as they depend upon a material instrument, are carried on.

But as we advance to the brain, the arrangement of cell and fibre becomes more complex, though in principle it is the same. Fig. 6 very roughly represents its structure. Tracing it upward from the spinal cord, the fibres of the latter are seen to expand in all directions, and among them various groups of cells are situated, while they are covered in by a layer of similar cells. This layer is folded up into "convolutions," so that though, if spread out, it would cover a surface of many feet, it is packed conveniently within the skull. If I might take a very homely illustration, I would suppose it was desired to spread as large a layer of sugar as possible upon a cake. The way to do it would be to indent the surface of the cake into deep close folds, and to arrange these in waving forms. These would be an image of the "convolutions" of the brain. And we cannot wonder that they are so extensive, when we consider that it is through the cells which cover them that the

FIG. 6.

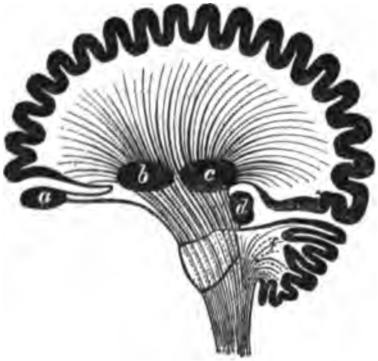


DIAGRAM OF A VERTICAL SECTION OF THE BRAIN.

a. Centre for smell. *b.* Centre for motion. *c.* Centre for sensation. *d.* Centre for sight. *f.* The little brain, or cerebellum. The black indented line represents the cells of the convolutions.

mind acts. The convolutions of the brain are the portion of the body through which the mental life, with all its immense variety of powers, is manifested. And, speaking in general terms, it is found that the extent of the mental faculties is in proportion to the number and variety of these convolutions. Here, then, we arrive at the very crown and summit of the human body—that for which all other parts exist. Not that the soul dwells here, or depends in any way upon this, more than on any other portion of the material frame that it controls; but it is when impressions from without reach this portion of the nervous system that they excite, not actions only, but thoughts and feelings. It is on reaching this part that mere nervous impulses awake ideas, arouse passions, start trains of reasoning, call forth exertions of the will.

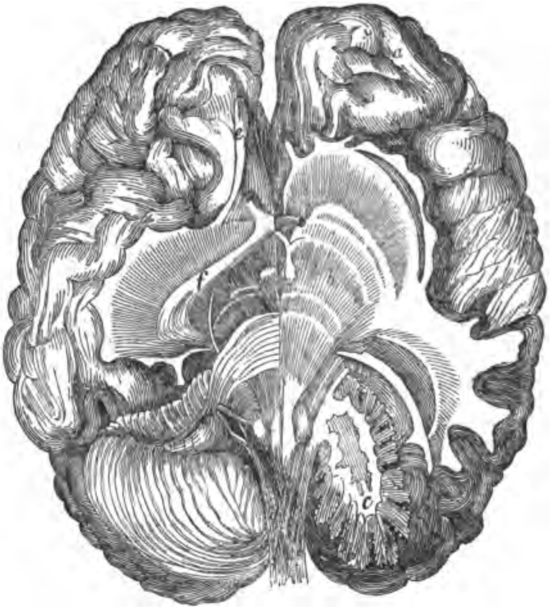
It seems a poor and simple mechanism for so great a result, and doubtless, till we have penetrated its secret, we cannot but think it so. Yet it is not quite so simple as it might appear. This chief of all the nervous centres is an expanse of small grey-coloured cells; altogether it is but about the tenth of an inch in thickness; yet, on minute examination, it has been found to consist of at least seven distinct layers; and though no decided difference between its various parts has been detected, there is proof that different portions of it serve different offices. Perhaps the best-established distinction of this kind is the dependence of speech upon a convolution situated in the region of the left temple. But upon points of this kind our knowledge, though very limited as yet, is growing fast.

It may be as well here to say, that the groups of nerve-cells are called *ganglia* (from *ganglion,* a knot) and that the cells are grey, while the nerves are white.

As I have said, the fibres of the spinal cord, as we trace them upwards into the brain, expand outwards and end in the convolutions, thus connecting every part of the body with the mind. But this connection is not direct and simple. Between the cord and the convolutions there are interposed two other large ganglia (see Figs. 6 and 7), which are connected, the lower with the nerves of sensation, and the higher with those of motion. In the former of these the impressions sent up to the brain from all parts are first received, and probably the multitude of them reduced into more distinct and simpler form, before they are transmitted onward. To the superior ganglion the impulses to motion arising from the will are first transmitted, probably as a simple or single mandate; and in the ganglion this mandate is distributed, we may perhaps say, to the various nerve-fibres, which set in operation the many muscles which must co-operate for every action. Besides thus ministering to the operations of the mind, these ganglia also possess a certain power of action in themselves. They also "reflect" impulses to the muscles or to the vessels, or the secreting glands, as well as pass them upwards to affect the mind. And they may do one or other of these in varying proportion, as the mind is more or less intent upon surrounding objects. Probably in "attending" to anything, what we chiefly do, so far as the brain is concerned, is to maintain the connection between the convolutions and these inferior groups of cells in a very free and active state; so that every impression, not only evokes an unconscious nervous response, but excites distinct ideas. The very quietness of a person who is earnestly attending may be taken as a proof of this. He exercises an active control over the unconscious reactions which would otherwise ensue in response to the impressions from without, which are affecting him on every side. This control is one of the actions which we perform through the convolutions.

The part of which we have been speaking is called the cerebrum; it is the brain properly so called, and consists of two hemispheres, which are shown in Fig. 7 (see also Fig. 1). These two hemispheres are intimately connected with one another by several sets of fibres, which pass in various directions from one to the other. What precise relations they bear to each other, and how far they are distinct in their use, is not yet fully known. But there is evidence that they have to some extent separate offices. The

FIG. 7.



THE COURSE OF THE NERVE FIBRES IN THE BRAIN.

a. The hemispheres. *b.* The central ganglia—of sensation and motion. *c.* The cerebellum, or little brain. *d.* The crossing of the fibres in the spinal cord. *e.* The nerve of smell. *f.* The nerve of sight. (This figure shows the inferior surface of the brain, part of which is cut away.)

most striking instance as yet known of this is the fact, only recently discovered, that disease of a certain part of the left side destroys the power of speech, which disease of the right side has not been observed to do. Each half of the brain is connected by its nerves with the *opposite* side of the body; the fibres crossing in the spinal cord, as seen in Fig. 7.

Besides this brain proper, or cerebrum, there is also contained within the skull a lesser brain, or cerebellum (Fig. 6, *f*; Fig. 7, *c*). This lies at the posterior and inferior part of the cerebrum, and is connected in the same way with the fibres of the spinal cord, and the two brains are intimately connected together. In structure the cerebellum corresponds very closely to the cerebrum. It also contains a group of cells in the centre, and is covered with a layer of cells externally, also arranged in convolutions; but these are very closely arranged, so as to represent on section an appearance like a tree (hence fancifully called the *Arbor Vitæ*, or "Tree of Life:" see Fig. 7, *c*). So far as is yet known, the office of this lesser brain is to regulate and harmonise the movements of the muscles.

As the brain-fibres spread out into the hemispheres of the great and little brain, they diverge from each other towards either side, and are again folded over upon themselves, so as to leave in the centre a series of small cavities, which are called the "ventricles of the brain." Through these spaces blood-vessels pass in and out, and these internal cavities, as well as a narrow space around the brain and cord, are filled with a watery fluid, which gives these organs the most equal and gentle support in all directions, and does very much to guard them from shocks and jars. This watery fluid is included in a firm bag of membrane folded all around the brain, and this bag is lined on the inside by a very delicate membrane full of blood-vessels, which dips down between all the convolutions, and feeds all the cells with a rich supply of blood. Outside of it, and binding it to the skull, there is another membrane, tough and strong.

We have thus given a very brief outline of the nervous system as it exists in man, and have seen that it consists of several distinct systems united into one. We may shortly sum it up by imagining—and the imagination strictly represents the truth—that there are in ourselves four distinct kinds of lives. First, there is a life which has to do with the mere growth and support of the bodily structure—which digests food, and circulates blood, and removes the products of decay. This life is carried on by a set of nerves and ganglia of its own, called the sympathetic, which has its chief seat around the stomach. Secondly, there is a life of movement, prompted by external impressions alone, without consciousness—a life of reflex action, as it is called; this has its seat in the spinal cord. Thirdly, there is a life similar to the last, but of a higher kind, such as we see manifested, for example, in the instincts of the bee; the seat of this is, probably, in the central ganglia of the brain. And, fourthly, there is the life of reason and of will, of which the convolutions are the instrument.

In the three lower forms of nerve-life, we have seen, the rule of action is that of simple reflection of impressions, with more or less of directness or of combination. In the highest form the law is modified, and instead of a mere reflection of force according to the nature of the impression, processes of thought and feeling are elicited, and results are varied according to the character of the man. But though the law is modified, it is not done away, and in the highest sphere of life instances are still met with of simple reflex action. This is exhibited in the most striking and interesting way in the form of *habits.*

As the child's powers advance with advancing age more and more actions, which at first required thought and an effort of the will, become drawn within the sphere of the unconscious and involuntary activity. Almost every action indeed—even the most complicated and difficult—which is habitually practised, becomes thus more or less independent of the will, and makes less and less demand on thought. In this consists, in part, the skill of the artist or artisan (who should always be truly an artist also). His hands pass almost unconsciously over his work, which is the better done, in truth, for this unconsciousness. We may convince ourselves of this by a trivial example. How easily we tie a bow, while we are thinking all the while of something entirely different! But let us direct our attention to the bow we are tying, and think of each step in the process, and the chances are we get puzzled, and bungle over it. It is the same in the execution of music, which would seem to require an attention so exact and unremitting. Instances have certainly occurred in which performers have lost their consciousness for a few moments, and have yet continued playing in perfect time. And in those almost more wonderful performances, which yet attract no wonder because they are universal—such as the function of speech, the act of walking, or the maintenance of the erect position—the working of the same law is seen. Our *words* almost form themselves; the mind is occupied exclusively with the matter. In walking, we take no thought to secure the movement of our limbs; nay, they may even take us where we would not. Often it has happened that a man absorbed in thought has walked, not where he meant, but where he has been used, to go. And that unceasing muscular play, whereby alone the body can be kept duly poised upon the feet in standing, though it takes the infant long to acquire it, entirely escapes the consciousness of the adult. All these and innumerable other actions essential to our well-being, the reflex nervous system takes by degrees upon itself, and thus ensures for us (at least until decay begins) a continual extension of our powers, and an ever-increasing possibility of concentrating them on moral and intellectual ends.

And thus, again, the study of our bodily structure enforces the highest moral lessons. The enlargement of the intellectual and moral nature, as it is one of our deepest religious duties, so it is also the road to the highest physical development. That is the most perfect condition of the nervous system in which its various parts are most thoroughly united in their operation, so that it acts completely as a whole. And this is only when the powers of each part are fully brought out, the subordinate portions discharging every function within their power, and the higher freely exercised on its appropriate objects. For thus only is it that each portion of the complex system transmits its full influence to the rest—an influence which is of the utmost importance to each. Of the importance of the healthy influence of the lower nervous system upon the higher, we have ample evidence in the impaired activity of mind, and the disordered and morbid state of the emotions, which accompany derangements of the digestive or circulating organs; and that the influence of the higher ganglia of the brain is not less important for the inferior nervous centres is proved by the effect on all the processes of life of prolonged or violent mental disturbance. How easily ill-news destroys the appetite, or the mere idea of a disgusting object excites nausea! The very thought of food increases the saliva and the gastric juice, while violent distress of mind will so derange the secretion of a mother's milk as to make it poisonous to her babe.

We see evidence, again, of the beneficial physical influence of a due exercise of the moral and intellectual faculties, in the improvement which ensues even in the bodily conformation of a race under the influence of good mental culture continued through a few generations. Not only does the contour of the skull and features become more noble, but the organs universally respond to the stimulus, and the whole frame gains in elegance, delicacy, and even in comparative vigour. Nor is the cause of this benefit arising from high mental exercise hard to discover. All action within the body is attended with the production of force, and no action more abundantly than that of the convolutions of the brain. This force radiates from the convolutions to the nerves throughout the body, supplying them with the healthiest of all stimuli, and one which the very structure of the nervous system proves that they were designed to receive. It cannot be withheld from them—as it is by indolent or grovelling thought—but to their detriment.

It is no argument against this statement that overtaxing of the brain, or a life passed in sedentary study, injures the health. Rather these are confirmatory facts; for the first proves the influence of brain-action over the whole body, and the second, while it shows indeed that exercise of other organs besides the brain is needed, proves at the same time that brain-exercise is good. For, however much a sedentary life of study may tend to debilitate (and, with good management, this is less than is often supposed), a sedentary life of mental indolence tends to debilitate much more. Mental indolence is bad even when combined with bodily exertion, but with bodily indolence as well, it is ten times worse. No constitutions are so morbid as those by which *no work* is done.

At the same time, mental work is apt to be over-strained, especially by those who most intensely feel its charms. One of the most frequent signs of this, when carried to a great extreme, is a morbid desire for suicide, which perhaps is really, at bottom, an unappeasable craving for rest. Some melancholy cases of self-destruction, which have excited the liveliest public regret, are clearly traceable to their cause in mental overwork. It is enough to mention Hugh Miller, and the great meteorologist Admiral Fitzroy. The first indications of any such temptation should be carefully observed, and rest taken in time. But rest for an overtaxed brain is not always easy to procure, even when no external circumstances render it difficult. An excited and over-stimulated mind *will* not rest, and to insist on resting it is often as futile as trying to go to sleep when we are not sleepy. A merely passive condition cannot at once be substituted for one of nervous restlessness. The true rest for a wearied brain is change to some unexciting yet *useful* occupation, with as much of the nature of service in it as possible, that the thoughts may be taken from ourselves; and the nearer it approaches to manual labour the better. Often a strong effort and a great sacrifice are required to achieve the change, but they are well rewarded. But, of course, in such cases medical advice should be taken.

One caution, in respect to mental exertion, it is well to remember—and that is, that it cannot be safely carried on, in any very great degree, at the same time with very severe bodily exertion. At least this is true of many persons, if not of all. The double tax upon the system is too great. And this should be remembered in respect to the condition of the labouring people. It is a doubly cruel wrong to inflict upon them an overtask; it condemns their minds, their hearts, to loss.

But much less injury to health is done by over-exertion of the nervous system in any legitimate occupation, than by the waste of nerve-power in the form of worry and useless vexation. All feelings of this kind consume force, and in addition propagate a deteriorating influence wherever a nerve-fibre goes. But here Physiology can but proclaim the want: it is Religion must supply the remedy. Contentment must be learnt from other pages than those which prove to us that the indulgence of vain desire is hurtful to our bodies. Yet even this lesson may not be in vain if it adds to our assurance that He who has thus made us incapable of too great a weight of care, makes no vain promise when He bids us cast our care on Him.

But there are also physiological reliefs to worry.

One is a full absorption of the mind on objects of wholesome interest. There is a case on record of a gentleman affected with signs of incipient insanity after great anxiety in business, who freed himself entirely from them by resolutely studying mathematics. And if we cannot all be students, helping others in their troubles is a resource always at hand, and never ineffective in aiding us to forget our own. Another relief lies in an improvement of the bodily conditions, which may often be brought about by very simple means, such as a better ventilation of our rooms, or a little more exercise in the open air. One of the most important laws to remember respecting the nervous system is, that its activity is prompted and regulated by external impressions, its object being emphatically to bring us into relation with the external world. Its health accordingly demands that these impressions should be transmitted to it in due abundance and of the right kind; and two of the chief sources from which they arise are the skin and the lungs. Hence, besides the primary necessity of fresh air to breathe, and pure water to wash in, for the needful purification of the blood, these have another use, only second in importance to the first—that of feeding, by the influx of pleasurable sensations, the very life of the brain. Hence the immediate exhilaration felt on drawing a deep breath of purer air, and the keen sense of enjoyment which follows a bath. It is not long before the blood, and through it the whole body, feels the influence of these beneficial agents; but the brain, through its quicker messengers, responds at once.

It is in all probability chiefly on a healthful supply of impressions through the skin and lungs that the pleasurable condition which we call a good "tone" consists. By these the brain is kept, as it were, girt up, and the man is possessed with a delicious half-consciousness of latent power.

The very opposite condition to this is that most wretched one in which every organ of the body seems to send to the brain its own special sensation of distress, and life becomes little else than a morbid feeling of the body. Sometimes this kind of suffering depends on deep-seated disease, and requires, even if it does not baffle, the utmost skill of the physician; but at others it is greatly the result of an unwise direction of the thoughts, and can be greatly amended by a resolute effort to divert them into more natural channels. The fact is, that thought directed to our own bodily organs is a violation of one of the main laws of our nervous system, which provides that all the vital processes shall be carried on by an unconscious mechanism. We cannot bring the brain to bear upon those parts of our bodily life which are committed to the inferior portions of the nervous system, without deranging brain and body alike. The nervous power thus sent in excess to organs already amply supplied, acts as a disturbing agent upon them; while, at the same time, abnormal channels, as it were, are opened from the lower ganglia to the convolutions, through which useless impressions, all of them painful, gain access to our consciousness. It is most important to avoid anything like a concentration of our thoughts upon any of the vital processes.

It is scarcely necessary to refer again to the influence which the emotions exert over the body, of which we are conscious every hour, alike in love or anger, hope or fear. Yet it may not be amiss to remark that the morally good emotions are more healthful than the contrary ones. Selfishness, cruelty, jealousy, rage, are slow poisons to the blood; all that produce happiness are cordials. But it did not need the advance of modern science to teach us how "a cheerful countenance doeth good like a medicine."

But one thing we have come to understand better in modern times, and that is, why too stern a control of the expression of emotion preys upon health; why *concealment* acts especially the part of the worm in the bud.

All emotions are attended with changes in the convolutions of the brain, and these changes generate a force which must operate in some way. The natural actions by which the passions express themselves are the channels provided by nature for this force, which thus contributes to the grace and dignity and joy of life; or at least provides signals of danger. But there is risk alike in the too free indulgence of these natural expressions, and in their absolute repression; the former tends to give passion too great a mastery over us, the latter forces the power which would thus innocently expend itself into hurtful channels. Thrown back absolutely upon the internal organs, the force which emotion generates deranges the operation of the other nervous centres, and may be the starting-point of lung disease. On similar grounds exercise is found a remedy for many forms of nerve distress. The over-excited brain is relieved by muscular exertions which tend to draw off its force.

But to attempt to point out all the relations which the nervous system bears to the other bodily powers would be an endless task. They intermingle at all points. It is happy for us that amid so much evidence of the subjection of the mind to the demands of its material servant, we can point to so much evidence of its freedom. The cases are not few in which the soul has soared in the highest regions while the body has been sinking under the most dire disease. Much of man's noblest work has been done with fainting hands, and amid pangs of agony; and, thank God, much more will be.

II.

THE FACULTY OF HEARING.

How low down in the animal creation the sense of hearing extends, it is not possible positively to say. It seems probable, however, that some at least of the insect tribe possess it. But it is first in animals like the lobster that an ear, though of the simplest construction, can be distinctly shown to exist. By careful looking, this ear may be found at the upper part of the second pair of feelers, in the lobster or the crab; and it consists of a very small bag, filled with a watery fluid, and covered in externally by a strong membrane. On the internal surface of this bag a nerve spreads itself out, which nerve carries the effect of the motions of the fluid to the brain—such brain as the creature has. A nerve and a little bag of water, accessible to the vibrations of the air, constitute an ear; and however complicated the ear may become in the higher animals and ourselves, as we shall see that it does, it always retains this character: it is, at the bottom, a bag of watery fluid and a nerve.

The next step towards making the ear more per-shell, of a tube winding around a central axis, and growing larger as it winds. The reason for this form we shall see hereafter. Birds and mammals and man possess it, though birds have it in a less perfect form. In them it is a curved tube something like a small boat, and not spirally arranged. Because, however, it is for the most part in the form of a spiral shell, it is called "the cochlea."

The sac, the three tubes, the spiral canal, then, make up the nervous part of the ear—*vestibule, semi-circular canals, and cochlea.* A wonderful structure, undoubtedly; and so the anatomists who first discovered it thought; for they called it *the labyrinth.* We will speak more of it by-and-by; for the present we will return to our codfish.

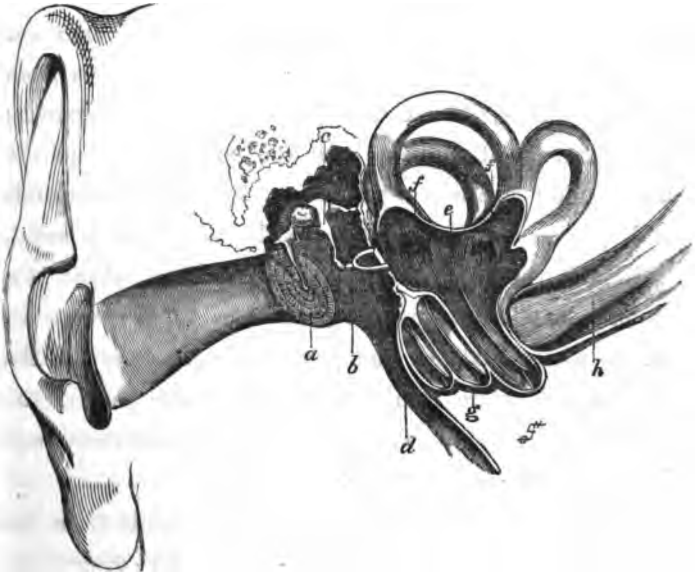
Though he, in common with the rest of his kind, hears very well, there is no external sign of his having any ear at all. The sac and its canals, with the auditory nerve expanded within them, constitute his whole organ of hearing, and they simply lie in contact with the inner surface of the skull. There is no membrane to receive vibrations from without, and pass them onwards. The reason of this is that water transmits vibrations so powerfully—much more powerfully than air—to solid bodies, that the bones of the fish's head suffice to convey sounds to the nerve. Except the whale, and the other water-inhabiting mammals (which have ears like their air-breathing fellows, though somewhat modified), animals which live habitually in water hear through the bones of the skull; and their ear consists only of the nerve and the fluid-containing membranous bag on which it is spread out. But for air-breathing animals this would not suffice. The air passes on its vibrations to the skull far too feebly to serve the purposes for which hearing is needed, and accordingly an apparatus is required for conveying the vibrations of the atmosphere, which constitute sound, to the nerve appointed to receive them. This apparatus answers to the transparent parts of the eye, which afford a free passage to the light, and constitutes the second or outer portion of the ear. It has many forms in various classes of animals, but all are framed upon one plan, and it will suffice if we describe it briefly as it is met with in ourselves.

The outer ear, though probably not without a certain amount of use, appears to exist in man chiefly for beauty's sake. In many animals, however, it is of great importance, being, in fact, a natural hearing-trumpet. Humboldt relates that, in South America, the troops of wild horses that traverse the country divide themselves, as regards the direction given to their ears, into three sets. Those which lead the van direct them forward, those in the centre turn them to the side, and the hindmost set them to the rear; so that the whole troop is made aware, in the acutest way, of danger threatening from any quarter.

The passage which leads inwards from the outer ear is slightly curved, and in adults is about an inch and a half in length; in children, however, it is much shallower, having a depth in the infant of scarcely half an inch. It is of oval form, and about its centre is furnished with a broadish ring of small glands which secrete the light brown semi-solid substance known as the ear-wax. At the bottom of this passage is fixed the membrane (Fig. 2, *a*) commonly called the "drum of the ear;" but not correctly; a drum being, not a membrane, but a hollow space closed on one or more sides by membrane. The membrane to which the external passage leads constitutes the outer side of a cavity hollowed in the bone (Fig. 2, *b*), which cavity is the drum of the ear, and contains several important parts.

First, there is the membrane itself, a beautiful structure, made up of fine fibres, some radiating from the central part to the circumference, others arranged in concentric rings; and it is lined on the outer side by a very fine layer of skin, and on the inner by an equally fine layer of cellular membrane. It is almost transparent, and though moderately strong, is little thicker than gold-beaters' skin. Being kept gently on the stretch, it thrills to every whisper, and two small muscles keep it in the most delicate adjustment to each varying impulse with which the air comes laden. One

Fig. 2.



VIEW OF THE HUMAN EAR, AS SEEN ON A SECTION FROM ABOVE DOWNWARDS.

a. The membrane of the drum. *b.* The cavity of the drum. *c.* The chain of bones. *d.* The tube leading into the throat (the Eustachian tube). *e.* The vestibule. *f. f.* Openings of two of the canals into the vestibule. The thin membranous parts in which the nerve is contained are supposed to be removed; see Fig. 4. *g.* The cochlea. *h.* Nerve of hearing.

of these muscles draws it tighter, the other loosens it, by acting upon a chain of very small bones (Fig. 2, *c*), which pass, suspended as it were in mid air, and swinging with every breath, across the drum, from the membrane to the nerve. This chain of bones answers two purposes:—First, it receives vibrations from the membrane, and conveys them to the labyrinth; and secondly, it adjusts both the membrane, and the fluid which surrounds the nerve, to the various kinds and pitches of sound by which they are affected.

Besides the membrane already described, there is a second smaller membrane opposite to it; that is, on the inner wall of the drum, which closes in the spiral canal before mentioned, in which one part of the nerve is spread out. The use of this second membrane is not yet fully determined.

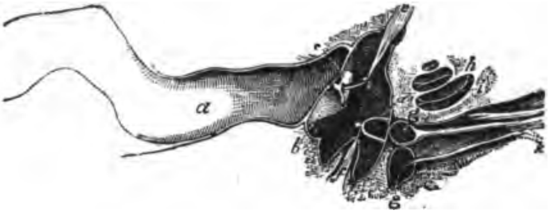
Lastly, a tube about two inches long leads from the drum into the throat, called, from its discoverer, Eustachius, the "Eustachian tube" (Fig. 2, *d*). The use of this tube is twofold. First, it supplies the drum with air, and keeps the membrane exactly balanced, and free to move, with equal air-pressure on each side; and, secondly, it carries off any fluid which may be in the drum, and prevents it from being choked by its own moisture. It is not always open, however, but is opened during the act of swallowing, by a little muscle which is attached to it just as it reaches the throat. Most persons can distinctly feel that this is the case, by gently closing the nose and swallowing; when a distinct sensation is felt in the ears. This sensation is due to a little air being drawn out of the ears through the open tube during swallowing; and it lasts for a few minutes, unless the air is again restored by swallowing with the nose unclosed, which allows for the moment a free communication between the ear and the throat. We thus see a reason for the tube being closed. If it were always open, all the sounds produced in the throat would pass directly into the drum of the ear and totally confuse us. We should hear every breath, and live in a constant bewilderment of internal sounds. At the same time the closure, being but a light contact of the walls of the tube, easily allows a slight escape of air *from* the drum, and thus not only facilitates and regulates the oscillations of the air before the vibrating membrane, but provides a safety-valve, to a certain extent, against the injurious influence of loud sounds.

The chief use of the Eustachian tube is to allow a free interchange of air between the ear and the throat, and this is exceedingly important; and it is very important also that its use in this respect should be understood. Persons who go down in diving-bells soon begin to feel a great pressure in the ears, and if the depth is great, the feeling becomes extremely painful. This arises from the fact, that in the diving-bell the pressure of the air is very much increased, in order to balance the weight of the water above; and thus it presses with great force upon the membrane of the drum, which, if the Eustachian tube has been kept closed, has only the ordinary uncompressed air on the inner side to sustain it. It is therefore forced inwards and put upon the stretch, and might be even broken. Many cases, indeed, have occurred of injury to the ear, producing permanent deafness, from descents in diving-bells, undertaken by persons ignorant of the way in which the ear is made; though the simple precaution of frequent swallowing suffices to ward off all mischief. For if the Eustachian tube is thus opened, again and again, as the pressure of the outside air increases, the same compressed air that exists outside passes also into the inside of the drum, and the membrane is equally pressed upon from both sides by the air, and so is free from strain. The same precaution is necessary in ascending mountains that are lofty, for then there is the same effect of stretching produced upon the membrane, though in the opposite way. The outside air becoming less and less condensed as a greater height is gained, the ordinary air contained within the drum presses upon the membrane, which is thus insufficiently supported on the outside, and a similar feeling of weight and stretching is produced. The conjuror's trick of breaking a vase by a word rests on the same principle. The air is exhausted from within, and the thin though massive looking sides of the vase collapse by the pressure of the air outside; and just as ever so small a hole made at the right moment in the side of the vase, would prevent the whole effect, so does swallowing, which makes a little hole, as it were, for the moment in the drum of the ear, prevent the in-pressing or out-pressing of the membrane. Mr. Tyndall, in his interesting book on *Sound*, tells us how he employed this precaution of swallowing, and with entire success, when, in one of his mountain excursions, the pressure on his ears became severely painful.

Deafness during colds arises very often, though not always, from a similar cause. For when, owing to swelling of the throat, the Eustachian tube cannot be opened by its muscle, and so the air in the drum is not renewed, the air that is contained in it soon diminishes, and the outer air presses the membrane in, so that it cannot vibrate as it should. This is what has been sometimes called "throat-deafness."

The two little muscles that stretch and relax the membrane of the drum are shown in Fig. 3, which represents a horizontal section of the ear. Each of them passes through a little pulley of bone, and that which relaxes the membrane is shut up in bone altogether except its tendon. One moves the bone that is attached to the membrane, drawing it inwards when it contracts; the other moves the bone which touches the fluid that surrounds the nerve, drawing it outwards,

Fig. 3.



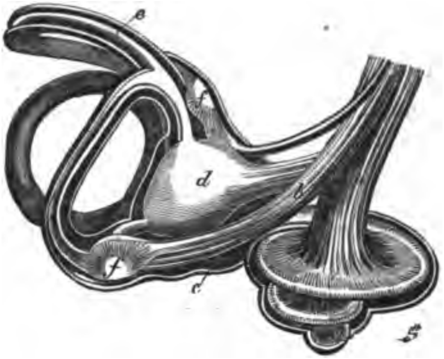
MUSCLES OF THE DRUM.

a. The meatus. *b.* The membrane of the drum. *c.* The bone attached to the membrane (called from its form the *malleus* or "hammer"). *d.* The bone which is in contact with the labyrinth (called the *stapes*, or "stirrup"). The bone which lies between these (see Fig. 2) is omitted; it is called the *incus* or "anvil." *e.* The muscle which stretches the membrane; its tendon passes round a little hook of bone, and then crosses the drum to be attached to the malleus. *f.* The muscle which relaxes the membrane (the bone being cut away to show it). It is attached to the stapes, which it turns slightly on its axis and draws outwards. *g. g.* The two membranous sacs which make up the vestibule, and which are on the same plan as in the salmon (see Fig. 1). *h.* The cochlea. *i.* The plate which winds around the central axis of the cochlea, and on which the nerve is spread out. This plate divides at its outer part into two layers, forming another very minute canal. *k.* The nerve, which is seen divided into its three branches.

and letting the membrane fall back again. It will be noticed that the membrane is not placed straight at the bottom of the passage, but slants inwards, and is besides drawn a little inwards at the centre, through being attached to a small rod of bone, about a third of an inch long, which keeps it in its position. (See *a*, Fig. 2.) This little rod is part of the movable chain of bones, and upon it the muscle which stretches the membrane acts. The membrane is held slightly on the stretch by a small firm band which passes with the tendon of this muscle across the drum. Thus it is kept in tune for ordinary sounds, without needing a constant action of the muscle.

We may now leave the outer part of the ear, designed for conducting sound to the nerve, and turn again, for a minute, to the labyrinth in which the nerve comes out to meet the sound. (See Fig. 4.) The central sac or vestibule, and the three canals with their expansions, we have already described. Besides the fine powder these parts contain, which is seen under the microscope to consist of little oval crystals scattered among the minute fibres of the nerve, they are provided also in some cases, with a number of delicate hairs, by means of which the motions of the small crystals are no doubt rendered still more sensible. All these parts are hollowed in the solid bone—the hardest bone in the body; it is called by anatomists the rockbone.* The delicate membrane in which the nerve is expanded lies in smooth rocky channels, floating in a limpid fluid, which at once surrounds and fills it.

FIG. 4.



THE LABYRINTH.

a. Nerve passing to the cochlea. *b.* Nerve passing to the vestibule. *c.* The bone surrounding the vestibule and the semicircular canals. *d.* The sac of the vestibule. *e.* The membranous canals. *f. f.* The enlargements on the canals, in which, and in the vestibule, the nerve is expanded.

This is separated from the drum by a thin wall of bone, and in this wall the chain of small bones that passes across the drum ends. The chain terminates in a little oval plate, moving lightly to and fro, like a minute piston in a very shallow cylinder. (See Fig. 3, *d.*) If this little piston will not move (which again may be a result of "colds"), there is another cause of deafness.

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* The "petrous" portion of the temple bone. The word is the same as that from which the Apostle Peter—the Rock—received his name.

One word we must still devote to the second part of the labyrinth—the shell-like spiral canal (or cochlea) Fig. 4. This, too, is hollowed in the bone, and its very form tells the story of its use. For as the canal, from being exceedingly minute, becomes larger and larger, it gives space for the arrangement of a series of little vibratile chords or fibres, of gradually increasing length (such as the wires of a pianoforte may roughly represent).

These little fibres respond, each of them, to a certain pitch of sound, and are connected each with its own nervous twig. And as in the two turns and a half which the cochlea makes, there are many thousands of these vibratile fibres, ample provision is made for all the immense variety of notes and modulations which our ears are called on to receive. By means of the sac and the canals we are made conscious of mere noises, such as the tick of a watch or the rumbling of a waggon; by means of the cochlea we appreciate music and understand the voice.*

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* This is the view of the cochlea which Helmholtz has done so much to render probable. It is supported, not only by the minute anatomy of the organ, but by many curious peculiarities of hearing. There are persons living who can carry on conversation without much difficulty, but

Thus, according to the number of the fibres in the cochlea, and the pitch to which, we may say, they are *tuned*, will be the number and the pitch of the different sounds which we can distinguish; and this differs in different persons, especially in respect to the higher notes. There are many persons who hear well enough, yet who never heard the high shrill note of the cricket. And when a sound is made to rise gradually higher and higher, different persons cease to hear it at different times.

This is but a poor and partial account of a wonderful organ, of which those who know most have still very much indeed to learn. There is much in it to excite our wonder; but, above all, we cannot but stand in amazement before the question: How is it that the motion of the air, the vibration of the membrane, the trembling of the fluid, should impress us with the feeling of a *sound;* should hold us rapt as music does, or thrill us with ecstasy in the tones of a voice we love? That is the great mystery of all the senses. We cannot penetrate it yet; but we can feel, and ought to feel, how wonderful it makes the world. That which seems mere motion in the ear, and in the nerve, turns into joy or

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who cannot hear sounds of a high pitch, not even a railway whistle; and others who can hear a watch tick well, but can scarcely hear music or spoken words.

sorrow in the soul: it is the source and instrument of aspiration, the vehicle of prayer. If it is all this to us, what must it be to God, who made it, and knows it perfectly?

All the structures that have been described are means used to bring sound from the outer air to our brains, in order that we may hear. Every condition is fulfilled; every step fully prepared for. Nothing is slurred over, nothing omitted, or half done. And it is so all through the world. There is no *slovenliness* in Nature's work; no grasping at quick ends, and grudging of the means; for every result the full equivalent is given. This is God's choice; the mode He takes of working. And he who tries or wishes to do otherwise, to take short cuts, or get results without full work performed, thinks himself wiser than his Maker.

There are several things very commonly done which are extremely injurious to the ear, and ought to be carefully avoided. Those who have followed the previous description will easily understand the reason.

And first, children's ears ought never to be boxed. We have seen that the passage of the ear is closed by a thin membrane, especially adapted to be influenced by every impulse of the air, and with nothing but the air to support it internally. What, then, can be more likely to injure this membrane than a sudden and forcible compression of the air in front of it? If any one designed to break or overstretch the membrane, he could scarcely devise a more effective means than to bring the hand suddenly and forcibly down upon the passage of the ear, thus driving the air violently before it, with no possibility for its escape but by the membrane giving way. And far too often it does give way, especially if, from any previous disease, it has been weakened. Many children are made deaf by boxes on the ear in this way.

Nor is this the only way in which injury follows: if there is one thing which does the nerve of hearing more harm than almost any other, it is a sudden jar or shock. Children and grown persons alike may be entirely deafened by falls or heavy blows upon the head. And boxing the ears produces a similar effect, though more slowly and in less degree. It tends to dull the sensibility of the nerve, even if it does not hurt the membrane. I knew a pitiful case, once, of a poor youth who died from a disease of the ear. He had had a discharge from it since he was a child. Of course his hearing had been dull; and what had happened was that *his father had often boxed his ear for inattention!* Most likely that boxing on the ear, diseased as it was, had much to do with his dying.

And this brings me to the second point. Children should never be blamed for being inattentive, until it has been found out whether they are not a little deaf. This is easily done by placing them at a few yards' distance, and trying whether they can understand what is said to them in a rather low tone of voice. Each ear should be tried, while the other is stopped by the finger. I do not say that children are never guilty of inattention, especially to that which they do not particularly wish to hear; but I do say that very many children are blamed and punished for inattention when they really do not hear. And there is nothing at once more cruel and more hurtful to the character of children than to be found fault with for what is really their misfortune. Three things should be remembered here:—1. That slight degrees of deafness, often lasting only for a time, are very common among children, especially during or after colds. 2. That a slight deafness, which does not prevent a person from hearing when he is expecting to be spoken to, will make him very dull to what he is not expecting: and 3. That there is a kind of deafness in which a person can hear pretty well while listening, but is really very hard of hearing when not listening.

The chief avoidable cause of deafness is catching cold, and whatever keeps us from colds helps us to preserve our hearing. We should do, therefore, those things that help to keep colds away: of which the first is taking plenty of fresh air; the second using enough, but not too much, cold water all over us, taking especial care to rub ourselves thoroughly dry, and never to let it chill us; and the third is to avoid draughts and wet, especially sitting in wet clothes, or being in close or very heated rooms. But there are some kinds of colds especially hurtful to the ear. One is sitting with the ear exposed to a side wind, as too many people do now on the roofs of omnibuses, and so on. We should always *face* the wind; then, if we are not chilled, it is hard to have too much of it. Another hurtful thing is letting rain or sleet drive into the ear, against which, if it were not that people do sometimes suffer from this cause, it would seem as if it could hardly be necessary to caution them.

Another source of danger to the ear, however, arises from the very precautions which are sometimes taken against those last mentioned. Nothing is more natural than to protect the ear against cold by covering it with a piece of cotton wool; and this is most useful if it is done only on occasions of special exposure, as when a person is compelled to encounter a driving storm, or has to receive on one side of the head the force of a cutting wind. But it is astonishing in how many cases the cotton wool thus used, instead of being removed from the ear when the need for it has passed, is pushed down into the passage, and remains there, forming itself an obstruction to hearing, and becoming the cause of other mischiefs. Three separate pieces have sometimes been found thus pushed down, one upon the other. Paper rolled up, which is also used for protecting the ear when cotton wool is not at hand, is still more irritating when it is thus left unremoved. The way to avoid this accident, besides being careful not to forget, is to use a large piece of the wool, and to place it over, rather than in, the passage.

It should be remembered that constantly covering up the ear is adapted to injure it. On the whole, men, in whom the ear is habitually exposed, suffer if anything less from ear-disease than women, in whom it is so often covered. Nor can the "hat" be held an unsafe head-dress in this respect for the latter sex. But it is important that there should not be frequent changes, especially in cold weather, from a head-dress which covers to one which exposes the ear. It is better that the air should always have free access to it; but if this has not been the case, the summer should be chosen to make the change.

All sorts of substances are sometimes put into the ear by children, who do it to themselves or to each other in ignorant play. If every parent and teacher warned his children against doing this it would not be a useless precaution. When the accident happens, the chief danger is that of undue haste and violence. Such bodies should be removed by syringing with warm water alone, and no attempt should be made to lay hold of them or move them in any other way. It is enough to reflect, again, that the passage of the ear is closed by a delicate membrane to show the reason for this rule. When no severe pain follows, no alarm need be felt. It is important that the substance should be removed as speedily as is quite safe, but there need never be impatience; nor should disappointment be felt if syringing needs to be repeated on many days before it effects its end. It will almost invariably succeed at last in the hands of a medical man, and is most effective if the ear is turned downwards, and syringed from below.

Now and then an insect gets into the ear and causes great pain: the way to get rid of it is to pour oil into the ear. This suffocates the insect.

There is another danger arising from boyish sports. Snowballs sometimes strike the ear, and the snow remaining in it sets up inflammation. This danger is increased by a practice which should be inadmissible, that of mixing small stones with the snow, which thus effect a lodgment in the ear. Care should be taken that no water remains in the passage.

Among the causes of injury to the ear must unfortunately be reckoned bathing. Not that this most healthful and important pleasure need therefore be in the least discouraged; but it should be wisely regulated. Staying too long in the water certainly tends to produce deafness as well as other evils; and it is a practice against which young persons of both sexes should be carefully on their guard. But independently of this, swimming and floating are attended with a certain danger from the difficulty of preventing the entrance of water into the ear in those positions. Now no *cold* fluid should ever enter the ear; cold water is always more or less irritating, and if used for syringing rapidly produces extreme giddiness. In the case of warm water its entrance into the ear is less objectionable, but even this is not free from disadvantage. Often the water lodges in the ears and produces an uncomfortable sensation till it is removed: this should always be taken as a sign of danger. That the risk to hearing from unwise bathing is not a fancy, is proved by the fact, well known to lovers of dogs, that those animals, if in the habit of jumping or being thrown into the water, so that their heads are covered, frequently become deaf. A knowledge of the danger is a sufficient guard. To be safe it is only necessary to keep the water from entering the ear. If this cannot be accomplished otherwise, the head may be covered. It should be added, however, that *wet hair*, whether from bathing or washing, may be a cause of deafness if it be suffered to dry by itself. Whenever wetted, the hair should be wiped till it is fairly dry. Nor ought the practice of moistening the hair with water to make it curl to pass without remonstrance. To leave wet hair about the ears is to run great risk of injuring them. In the washing of children, too, care should be taken that all the little folds of the outer ear are carefully dried, and gently, with a soft towel.

But I come now to what is probably the most frequent way in which the ears are injured: that is, by the attempt to clean them. It ought to be understood that the passage of the ear does not require cleaning by us. Nature undertakes that task, and in the healthy state fulfils it perfectly. Her means for cleansing the ear is *the wax*. Perhaps the reader has never wondered what becomes of the ear-wax. I will tell him. It dries up into thin fine scales, and these peel off one by one from the surface of the passage, and fall out imperceptibly, leaving behind them a perfectly clean smooth surface. In health the passage of the ear is never dirty; but if we attempt to clean it, we infallibly make it so. Here—by a strange lack of justice, as it would seem, which, however, has no doubt a deep justice at the bottom—the best people, and those who love cleanliness, suffer most, and good and careful nurses do a mischief negligent ones avoid. Washing the ear out with soap and water is bad; it keeps the wax moist when it ought to become dry and scaly, increases its quantity unduly, and makes it absorb the dust with which the air always abounds. But the most hurtful thing is introducing the corner of the towel screwed up, and twisting it round. This does more harm to ears than all other mistakes together. It drives down the wax upon the membrane much more than it gets it out. Let any one who doubts this make a tube like the passage, especially with the curves which it possesses; let him put a thin membrane at one end, smear its inner surface with a substance like the ear-wax, and then try to get it out so by a towel! But this plan does much more mischief than merely pressing down the wax. It irritates the passage, and makes it cast off small flakes of skin, which dry up, and become extremely hard, and these also are pressed down upon the membrane. Often it is not only deafness which ensues, but pain and inflammation, and then matter is formed which the hard mass prevents from escaping, and the membrane becomes diseased, and worse may follow. *The ear should never be cleaned out with the screwed-up corner of a towel.* Washing should extend only to the outer surface, as far as the finger can reach.

Ear-picks, again, are bad. If there is any desire to use them it shows that the ear is unhealthy; and it wants soothing, not picking. And there is another danger from introducing any solid thing into the ear. The hand may get a push, and it may go to far. Many is the membrane that has thus been broken by a bodkin. Sportsmen sometimes have their membrane pierced by turning suddenly while getting through a hedge. And it even happens that a boy at school may put a pen close to another's ear, in play, and call to him to make him turn his head; and the pen pierces the membrane.

Very loud sounds may cause deafness, too. Artillerymen, and also eager sportsmen, and very zealous volunteers, incur a danger from this cause. It is well to stop the ears when exposed to loud sounds, if possible; also to avoid belfries when the bells are about to ring. A man who was once shut up in one, became stone deaf before the peal was done. The sound of guns is more injurious to those who are in a confined space with them, and also if the mouth be open. Injury from loud sounds, also, is much more likely to occur if they are unexpected; for if they are anticipated, the membrane is prepared for them, without our knowledge, by its muscles. At certain points on the Rhine, it is, or was, the custom of the captain of the steamboat to fire a small cannon, to exhibit the echo. When this has been done without due warning, it has proved more than once a cause of lasting deafness. Sometimes these loud sounds rupture the membrane; sometimes they deaden the nerve: the former is the least evil.

It is a bad practice, also, to put cotton-wool soaked in laudanum or chloroform into the ear for the relief of toothache. It may be sometimes effectual, for the nervous connection between the teeth and the ear is very close. But the ear is far too delicate and valuable an organ to be used as a medium for the application of strong remedies for disorders of other and less important parts; and laudanum, and more especially chloroform, are powerful irritants. The teeth should be looked after in and for themselves, and if toothache spreads to the ear, that is the more reason for taking them thoroughly in hand; for prolonged pain in the head, arising from the teeth, may itself injure the hearing.

When a child's ear becomes painful, as it so often does, everything should be done to soothe it, and all strong irritating applications should be avoided. Pieces of hot fig or onion should not be put in; but dry flannels as hot as can be borne should be applied, with poppy fomentation if the pain does not soon subside. How much children suffer from their ears, unpitied because unknown, it would probably wring the hearts of those who love them suddenly to discover. It is often very hard, even for medical men, to ascertain that the cause of a young child's distress is seated in the ear, and frequently a sudden discharge from it, with a cessation of pain, first reveals the secret of a mysterious attack, which has really been an inflammation of the drum. The watchfulness of a parent, however, would probably suffice to detect the cause of suffering *if directed to this point,* as well as to others. If children cry habitually when their ears are washed, that should not be neglected; there is, most likely, some cause of pain. Many membranes are destroyed from discharges which take place during "teething." Whenever there is a discharge of matter from the ear, it would be right to pour in warm water night and morning, and so at least to try and to keep it clean. But into the treatment of diseases of the ear it would not be suitable to enter here.

III.

THE EYE AND SIGHT.

SIGHT is perhaps, taken singly, the most valuable of our natural faculties. To the lower animals and to uncivilized man it is of an importance which it is not easy to exaggerate; but it has become to ourselves, through the introduction of writing and of the printing press, of—shall I say?—tenfold worth. The high value set upon the eye is indicated by many figurative expressions in daily use; and every one must have noticed the instinctive pride we all feel in the possession of good sight. People will boast of their sight who are beyond boasting of anything else; and those who unfortunately are obliged to admit that now the faculty is failing, will still find comfort in assuring you that in early life they were "remarkable for strong sight." Those whose sight has failed, almost always date the commencement of their defect quite recently, often long since the time at which it must have begun. Whilst this instinctive sense of its value renders some people painfully apprehensive as to very slight symptoms, it renders others—and the majority—absolutely unable to admit, even to themselves, that there is anything the matter. Surgeons who practise in diseases of the eye often meet with curious illustrations of this, and often have difficulty in convincing those who have in reality lost half of what they ought to possess, that they are not rich.

Observing the immensely increased value of sight to civilized men, it is a matter of congratulation that blindness is far less frequent among them than among savages. With a little allowance for the effects of climate and of occupations, it may be asserted that the higher the civilization, the smaller the proportion of those who are blind, or who suffer from irremediable defects of sight. In England, perhaps, it is smaller than in any other part of the world. In Egypt, India, China, and Japan, the number is very large indeed; and one of the most valuable qualifications of the medical missionary is a knowledge of this part of surgery. The way in which civilization brings about this splendid result—one for which we can never be too thankful—is partly by improving the general sanitary state, diet, clothing, etc., but chiefly by the increased care of the organs and the scientific treatment of their diseases.

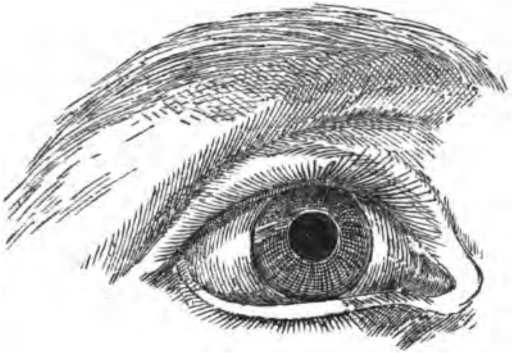
Even in England there is still much that might be done towards the preservation of this valuable faculty, were the true nature of its disorders better understood; and it is not only amongst medical men that a wider diffusion of knowledge in this matter is to be desired, but also amongst the public at large.

In the following article the endeavour will be made, not only to exhibit the eye and its endowments as an interesting lesson in physiology, but also to supply information as to some of the common causes of its failure, and the best means for their prevention or remedy.

We will speak first of the parts which are seen on looking at the front of the eye. In order to better understand and remember what is described, the reader will do well to borrow a friend's face for a few minutes' close examination.

First we have THE EYELIDS. These are two movable folds of skin intended to protect the eye. In order to stiffen them and make them fit well, there is placed in each a narrow strip of gristle (or cartilage). You will observe that the upper lid covers the eye rather more than the lower; that the edge of the lower lid is nearly straight—that of the upper arched; and, lastly, that the upper lid moves more freely than the lower one. The upper lid can be lifted at will considerably; but the lower one can be but very little drawn down. Both can be moved freely in the act of closing the eye. The upper lid has a special muscle by which it is lifted. The muscle by which we close the lids is common to both. Under each lid there is a sort of pouch, or hollow, which may be easily seen in the case of the lower lid by drawing it down. Into these pouches little particles of dirt, insects' wings, bits of chaff, straw, etc., sometimes get, and there lie hid, causing much irritation to the eye. From such positions they are often difficult to dislodge. They lie out of sight, and it is necessary to turn the lid over to expose and remove them. This should be done by a surgeon. If surgical aid be not at hand, it is sometimes possible, by taking a hair and doubling it, and then pushing the noose up under the lid, to draw them out.*

FIG. 1.



THE EYELIDS WITH LASHES, ETC.

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* These remarks apply only when the intruding body is under the lid, not when it is simply on the front of the eye. From the latter situation

At their outer corner the two lids meet and join at a sharp angle, but at the inner corner they do not quite meet, but leave a little round space between them. In this inner corner you will observe a red, fleshy-looking mass, about the size of a pea; this is a gland, which is of much larger size in some of the lower animals than it is in man. It is in the little pond, or hollow, which exists at the inner corner of the lids, that the tears collect before they escape away into the nose. When a person cries, the tears are so freely poured forth, that they cannot all escape by the channels to which I refer, and, in consequence, run over the cheeks. In a certain sense we may be said, however, to be always crying quietly. Tears are constantly being formed, and having passed over the surface of the eye, escape without observation into little channels which lead into the nose. A sharp-sighted person may easily find the opening (close to the inner corner of the lower eyelid) into which the tears enter. The lid must be held down, and it will then be seen as a round dot, about large enough to admit a pin. There is another

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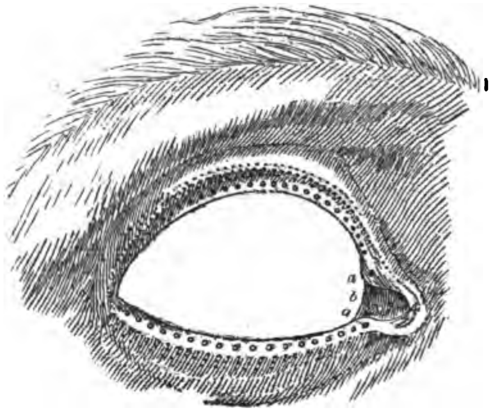
the best way to remove it is to oil the end of a finger, and then carefully touch the eye; this is easily borne, if gently done. The finger end may be covered with a soft handkerchief; its front surface, not its tip, should be used. Olive oil or castor oil will do; the latter is the better for the purpose.

in the upper lid, but it is not so easy to find. If a pin were pressed into this little hole, it might, if dexterously managed, be made to find its way inwards and downwards into the nose, for there is an open tube or channel the whole way. Many troublesome diseases result from the stopping up or narrowing of these delicate canals, the chief symptom of which is the overflow of tears on any slight irritation—such, for instance, as exposure to wind.

FIG. 2.



THE EYELIDS WITHOUT LASHES, ETC.

(*From Quain's Plates.*)

a, a. The openings of the tubes for the escape of tears. *b.* The little pond at the angle of the lids in which is placed the body known as the "caruncle."

As regards the formation of tears, it is necessary to remark that, although formed in part by a sort of oozing from the whole surface of the eye, they are chiefly poured out by a large gland provided for that special purpose, and placed deeply above and to the outer side of the eyeball. From its position, the water it forms must pass over the surface of the eye before it can escape at the inner corner. By this arrangement the eye is better washed, and any particles of dust, etc., are carried away.

At the margins of the lids we have **THE LASHES**; certain rows of stout hairs which grow in beautiful curves, and which serve both to adorn the features and to protect the eye. Close to the roots of the lashes there are, as is the case with all hairs, certain little glands, which form a sort of oil, and allow it to escape upon the hair, so as to keep it from drying and cracking. Near to the roots of the lashes, but not actually opening upon them, are also other and larger glands, which form a kind of wax; this being poured out at the edge of the lid keeps it always coated, and thus prevents the tears from running over it. You may see these glands by drawing the lower lid down. They look like little yellow streaks about a quarter of an inch long, and appear to be somewhat knotted. In the woodcut we have shown, first, an inner row of small holes, the openings of the glands, and, secondly, a number of yet smaller holes outside these, and arranged rather irregularly in two or three rows; these are the openings from which the hairs have been pulled out. At the inner corner of both upper and lower lid, a large black dot marks the opening of the canal for the escape of the tears towards the nose. All these glands are liable in certain states of the health, and especially after measles in delicate children, to inflame, and a sore-looking red edge to the lid is then produced. To cure this, in bad cases, surgeons often pull out all the lashes, and sometimes repeat the process several times. The lashes always grow again, and usually better than before. About six weeks is long enough for them to be reproduced in full perfection.

Now look at THE FRONT OF THE EYE ITSELF. You will notice a round part like a watch-glass, about the size of a sixpence, and set in a white structure which surrounds it. This white structure extends backwards out of sight completely round the eyeball, and is its chief coat or wall. It is called the *sclerotic*, from a Greek word, signifying that it is dense and strong. The clear part, which I have compared to a watch-glass, is called the "cornea." Through this clear cornea you look into the eye, and we now have to observe two parts, the black part in the middle, called the "pupil," and the coloured part which surrounds it, called the "iris." The cornea is convex, like a watch-glass; the iris is flat, like the watch-face. Between the cornea and the iris a few drops of clear water are placed. Now let us try the effect of light upon the iris and pupil. Close one eye altogether; shade the other with the hand for half a minute; and then suddenly expose it to a bright light. You will find that the pupil enlarges very much when shaded, and closes when exposed to light. This is effected by the iris, which is a sort of screen, attached only at its rim, and with a hole (the pupil) punched through its middle. In noticing its contraction on exposure to light, you have learnt the chief use of the iris; it is a shade intended to shut off glare, and to regulate the quantity of light admitted. Look at the pupil of a young child, and compare it with that of an adult, and then with that of an old person. You will find the child's large, that of the adult smaller, and that of the old man very small, perhaps little larger than a pin's head. The size and brilliant blackness of the pupil have much more to do with the expression of the eye than has the colour of the iris. Hence the comparative want of expression and of lustre in the eyes of old persons, and much of the sparkling beauty of the eyes of the young. An unusually large pupil generally implies delicacy of constitution. The fact that it gives expression to the eye has, however, been so fully recognised, that, in Italy, ladies are reported to employ a drug for the purpose of obtaining it. This drug has from that circumstance received the name of "belladonna," or "the beautiful lady." It is needless to say, however, that its use confuses the sight, and that such fancied beauty is very unwisely purchased.

Now let us look closely at the IRIS, and admire the beauty of its structure. That the colour of the iris may vary in different persons, every one knows; for it is this structure which gives what is called the colour of the eye. You will see, on minute inspection, that its colour varies at different parts in the same person, and also that it presents various lines and markings of great complexity and beauty. The iris, although a great aid to distinct vision, is not essential; and now and then persons are born without it, who still enjoy tolerable sight. The iris is about as thick as stout blotting-paper; and, whatever may be its colour in front, it is always of a deep brown, almost black, behind.

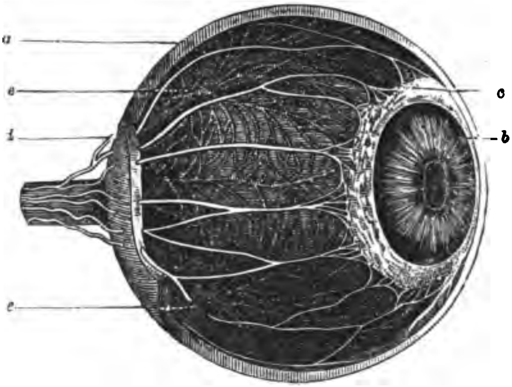
I have already said that the pupil (the black round part in the middle) is merely a hole through the iris. It looks black, just as a hole into a dark room would do; but the structures behind it are quite clear and colourless. It is through this hole, the pupil of the eye, that the rays of light enter.

With this brief description of the pupil and iris, ends what I have to say as to the structures which can be seen on looking into another person's eye. Before proceeding to explain the yet more important ones which lie out of view, I must ask attention to a few other points.

The eye, as every one knows, is "a very sensitive organ." Why is this? Because it is richly supplied with nerves. Every movement of the eyelids, every alteration in the size of the pupil, is accomplished through the means of these nerves, which, like so many microscopic telegraph-wires, connect the various parts, and send messages between them with vast rapidity. Is there too much light, the iris is ordered to contract; is the glare extreme, the lids also are made to close. The influence of the nerves does not, however, end here. Through their power the flow of tears may be increased or lessened. If a particle of dust is lodged in the eye, pain is the result; and this pain, quite apart from any effort of the will, makes the eye water, causes an overflow of tears, by which probably the offending body is washed off. Most persons are aware that one of the best ways of dealing with a gnat in the eye is to close the lids for a minute or two. A large accumulation of tears is the result, and on suddenly opening the lids the offending midge is carried away in the deluge.

In Fig. 3 we see exposed some of the nerve-trunks which supply the eye. Each one of these, although not thicker than a hair, would be found, on inspection

FIG. 3.



AN EYEBALL PARTIALLY DISSECTED.

(*From Holden's "Anatomy.*")

The thick white outer coat, sclerotic (*a*), has been cut away in most parts. In front the iris and pupil are seen (*b*, the iris). External to the iris is a ring of whitish structure, the ciliary muscle (*c*). At the back of the eyeball the great nerve of sight, the optic nerve, is seen entering the globe, and around it are twigs (*d*) of small nerves, which run forwards to supply the iris, ciliary muscle, etc. These nerves (*e* and *e*) are seen again after they have pierced the sclerotic. Under the nerve-trunks are seen the beautifully branching vessels which compose one of the inner coats of the eye (the choroid).

with a microscope, to consist of a bundle of very minute tubes, each isolated from its companion by a sheath, much as telegraph wires are cased in gutta-percha and then put together in one rope. These nerve-tubes have different duties to perform—some carry *to* the brain the sense of pain or other feelings (nerves of sensation), others carry *from* the brain orders to act, either to muscles or to glands. It is by these latter or motor nerves that the pupil is altered in size, and that we are able to fit the eye at one moment for looking at a distant prospect, at another for reading the smallest print. It is by the nerves which act on the glands that we regulate the flow of tears in crying, and by the irritation of which the eye "waters" when anything has got into it. If a certain branch of nerve were paralysed, the power of shedding tears on that side would cease, and the patient would be placed in the ludicrous position of being able to cry only with one eye. Such cases occur now and then.

I have omitted to say anything as to what may be called the skin of the eye. The lids are lined, and the front of the eyeball covered, by a very delicate, almost transparent membrane, which differs chiefly from skin in that it is constantly kept moist. It is continuous with the skin of the eyelids at their edges. On the front of the cornea it is quite transparent and invisible; but it is still there, as is proved in the case of serpents, which shed their skins once a year, and with it a perfect and unbroken membrane from the front of the eye. It is this membrane which chiefly carries the blood-vessels, and which becomes red in cases of inflammation. It is also well supplied with nerves. This membrane is technically called the *conjunctiva*, because it connects and covers in all the other structures.

Every one must have noticed how readily, even in persons in good health, the eyes sympathize with any slight disturbance. A bad night, or any temporary nervous exhaustion, will make the eyes feel heavy and "gritty," and will cause the lids to look swollen and red at the edges. The "lack-lustre eye" is proverbial; and to the general expression of "seediness" which follows a night of dissipation, the eye contributes perhaps more than any other part of the physiognomy. All these little changes are brought about by the influence of the nerves on the blood-vessels and other structures of the parts.

In almost every village there is some Lady Bountiful to whom the poor resort for "eye-water," when they need it. It is related of a French quack doctor, that having realised a large fortune by the sale of a secret remedy for ophthalmia, he was on his death-bed the subject of much compunction on the score that his specific had been, as he then explained, only river-water coloured. His surgeon told him to quiet his qualms, and assured him that it would be well for the public if all nostrums for this purpose were equally harmless. I think the surgeon was too severe. The household remedies in vogue usually consist of some weak mineral solution—alum, sulphate of zinc, and the like; and these remedies are very suitable to a large proportion of slight inflammations of the eye. Their chief evil is, not that they do actual harm, but that they often prevent those who ought to obtain proper and well-skilled advice from doing so sufficiently early. For slight colds in the eye, weak astringents such as those mentioned, or such as cold tea (a very popular remedy), are quite suitable; but let me enforce the rule, that on no account should they be trusted to when there is much pain or redness in the eye, nor in the inflammations which occur in infants.

Here I may suitably explain the real meaning of some expressions in popular use as regards diseases of the eye.

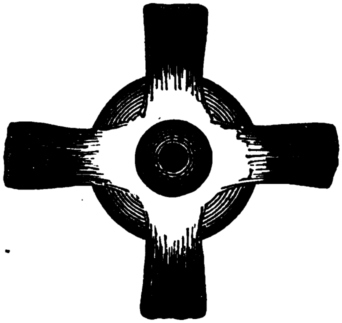
A "blood-shot eye" is an eye in which the minute blood-vessels are much enlarged, and thus parts which should have been white become more or less red. This condition generally implies inflammation.

A "watery eye," or—what is sometimes synonymous—a weak eye, means the condition produced when, owing to the stoppage of the minute channels for the tears, the latter find their way over the cheek. The term "weak eye" is often applied to states of long persisting inflammation of the roots of the eyelashes.

"White specks on the eyes" are produced whenever ulcers on the cornea, which ought to be perfectly clear, have healed and left scars. Such white specks are the natural result of the healing process, and are quite inevitable after many inflammations. As the ulcer heals, it becomes whiter and whiter; and then, after a long time, the film slowly clears away, and, in the course of years, may almost disappear. No surgical art can take these specks away, though certain operations may sometimes be performed for obviating their effect on sight.

A "cast" or "squint" is said to exist whenever the direction of one eye does not correspond with that of the other. In a state of health, the two eyes move together with admirable and instantaneous precision. If they did not do so, we should see two objects instead of one. A squint may occur either inwards or outwards. When inwards, which is by far the more common, the person becomes "cross-eyed," and obtains a peculiar sly expression, as if he were anxious to look in two places at once. When the squint is outwards, the defect in expression is greater, for it makes the countenance look somewhat silly and vacant. The movements of the eyeballs are accomplished by little slender muscles which adhere to its sides, and pull it, now in one direction, now in another. These muscles are chiefly four (see Fig. 4), one above, one below, and one on each side. The reader must not suppose that they stand off from the eye, as shown in the woodcut; on the contrary, they fit closely to its sides, like narrow strips of india-rubber on the sides of a marble. If any one of these muscles becomes either stronger or weaker

FIG. 4.



THE FOUR STRAIGHT MUSCLES OF THE EYE.

(From Holden's "Anatomy.")

The muscles are here shown lifted up from the ball, to exhibit their attachment on its front surface, not far behind the edge of the cornea and iris.

than its antagonist on the other side, a squint is produced. Surgeons cure squints by simply cutting the stronger muscle through, and thus weakening its hold on the eye. The operation is, to a dexterous hand, quite a simple one, and of course does not involve, as some fancy, "taking the eye out and turning it." Most persons who squint require spectacles, and many squints might be prevented by their timely use.

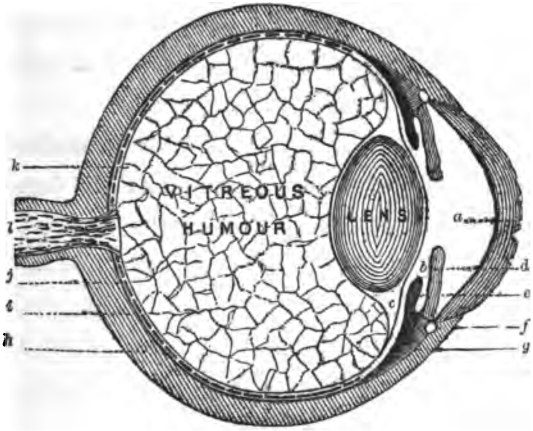
As I have said that unless the two eyes move accurately together, we see objects double, it will perhaps occur as a difficulty to some who may have experience of squinting, that these persons are not usually troubled with double vision. The explanation is this: When a squint first occurs, all objects are seen double. This is extremely perplexing and tiresome, and, to get rid of it, one eye learns not to see, or, to speak in professional language, one image is suppressed. Thus squinters use only one eye at a time. A very curious and instructive result follows on this disuse. The eye which is intentionally made to remain idle becomes almost blind. Now, if an eye had been disused in consequence of a large speck in front of it, or a cataract, it might have remained so for twenty years, and not have become blind; so great is the difference in result from enforced and from voluntary disuse! A sermon might be preached on this text. What a warning for the idle, and also for the ascetic! that we cannot voluntarily decline to use any of the faculties with which we are endowed, without risk of entire loss of that which we thus neglect!

We will proceed to try a few easy experiments.

1*st Exp.*—Look through the window, standing within a foot of the pane, and fix your sight on the particles of dust on the latter. By an effort, you can see them definitely and sharply. Now look out into the street or garden, but exactly in the same direction. You will find that when doing so you lose sight of the specks on the pane, and that to see them again you have to alter your eye, so that you do not see the distant objects. It is clear that your eye when looking at a near object and at a distant one is in different conditions. Now take an opera-glass or a child's telescope, and having adjusted it accurately for some object at a great distance, try to use it for a near one. You will find that the same adjustment will not do, and that you must alter the screw. Surely there is something in your eye which has the same effect as the screw of the opera-glass, and by altering its adjustment gives you the power of seeing accurately at one time the most distant objects, at others the nearest. We have said the nearest; but no, there is a limit here. It does not matter how far objects are off, provided they are large enough; the stars, the moon, etc., you can see them clearly, but not so with near objects. Try this page. Nearer than eight inches (if you have properly formed eyes) you cannot without a sense of straining effort read the type, and nearer than five all is blurred and indistinct. The same occurs with the opera-glass. You cannot by its screw adapt it for very near objects. With it, as with your eye, there is a limit to "adjustment" or "accommodation." We have found, then, that it is in looking at near objects that an effort has to be made, and hence the reason why small objects near to one are so trying to the eyes, whilst a distant prospect rests and strengthens them. Before we examine how accommodation is effected we must try another experiment.

2nd Exp.—Take any strong magnifying glass, and hold it at a little distance from a wall in front of a well-lighted window. You will find that it depicts upon the wall a much reduced picture of the window, and that this picture becomes bright or blurred according to your care in holding the glass at the correct distance. You cannot move it ever so little, either forwards or backwards, without disturbing the brightness of the image. Notice that the image is wrong side up, or inverted. Now the eye consists essentially of a magnifying glass thus used, and it paints pictures within itself exactly in the same manner. Certain parts are of course added to it, which much facilitate the performance, but the lens power is the essential. The lens is inclosed in a dark chamber, so that the brilliancy of the picture may not be damped by rays of light coming sideways; the iris is provided in front to regulate the quantity of light admitted; and lastly, we have a nerve-surface to receive

FIG. 5.



A SECTION OF THE EYEBALL FROM ABOVE DOWNWARDS.

a. The anterior chamber bounded in front by the cornea. *b.* The posterior chamber. *c.* The canal of Petit at the edge of the lens. *d.* The iris. *e.* The ciliary processes. *f.* The ciliary canal. *g.* The ciliary muscle (muscle of accommodation). *h.* The sclerotic. *i.j.* The two layers of the choroid. *k.* The retina. *l.* The optic nerve. N.B.—The lines in the *vitreous* humour represent its framework, but it must not be supposed that it is crossed by dark lines, as here shown; on the contrary, this framework, like the substance it incloses, is perfectly transparent.

the picture, and nerve-trunks to convey the impression to the brain. The lens power of the eye is produced in part by the cornea and its contents, in part by the "lens" itself, and in part by the vitreous humour behind it. Their combined power is about equal to a magnifying glass of one inch focus. You will see in Fig. 5 how they are arranged.

Now let us try to explain how "accommodation" is effected. In the case of the opera-glass it is done by the screw, which increases or lessens the distance of the glasses from each other. In the eye we have no screw, nor is it possible to materially alter the distance of the parts from each other. The result is gained by making the lens itself more powerful at one time than at another. This lens is placed just behind the pupil, and is about the size and shape of a small "acid-drop." It is of firm structure, but not hard, and is capable of being squeezed so as to become more convex. Fig. 6 shows its shape and size after removal from the eye. In Fig. 5 it is seen in place in the eye. Accommodation is, then, effected

FIG. 6.

by making this structure more or less convex, and this is done by a muscle which exists within the eye and surrounds the margin of the lens (see Figs. 3 and 5). Why accommodation should be necessary, we will next try to explain.

Every object that you can see becomes visible by the rays of light which it either gives off or reflects. Luminous objects, the sun, a candle, etc., originate their own rays; all others reflect those which they have received. If an object reflected no light, it would be black, and invisible. The type which you are now reading is in a strict sense invisible; it is the white spaces between the letters which reflect the light, and which are really seen. Now, rays of light always proceed in straight lines; they are capable, as we have seen, of being reflected or thrown back by any surface on which they strike; they are capable, also, let us now assert, of being refracted or bent out of their usual course by any transparent substance through which they pass. Transparent substances refract light in differing degrees according to their degree of density, and according to their external form. Our next assertion shall be, that all rays of light radiate, or, in other words, proceed from a point forwards in all possible directions. Make a dot near the edge of a sheet of paper, and then with a ruler draw as many straight lines from it as you possibly can, none of them quite touching anywhere but at the point of starting. This will give a good idea of how rays of light diverge, and how a pencil of light is formed. You will easily see that in no position could the pupil of the eye possibly receive all the rays of light, and that the farther off it was carried, the fewer it would get.

You may notice, also, in the diagram which you have

FIG. 7.

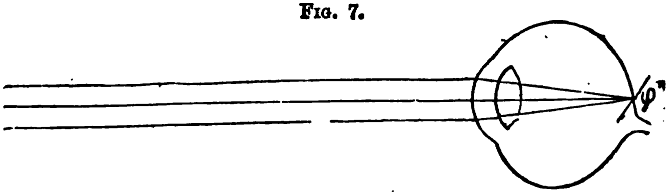


DIAGRAM OF AN EYEBALL OF EXACTLY NATURAL LENGTH.
(From Donders.)

Parallel rays are brought to a focus (ϕ'') by the lens, etc., at the bottom of the eye, precisely on the retina.

constructed, that the lines nearest the middle are those most nearly parallel to each other. The rest diverge more strongly.

Now, imagine that these lines were prolonged not only across your sheet of paper, but across a wide room, or across a field. Under such circumstances, only those rays which were in the middle, and nearly parallel with each other, could possibly enter an observer's eye; all the rest would have diverged and passed away to the sides.

Two things have, it is hoped, been made clear by these statements. First, we have shown why it is so difficult to see distant objects, unless they are of large size, or very well lighted; and, second, that we see distant objects by means of rays of light which are parallel, and near ones by the aid of rays which are divergent.

Fig. 8.

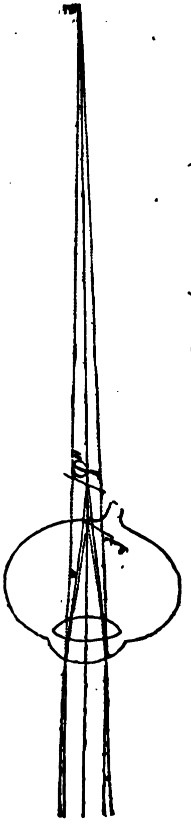


DIAGRAM OF AN EYEBALL MUCH TOO SHORT (WEAK-SIGHTED).

(*From Donders.*)

Parallel rays, instead of coming to a focus on the retina, do not meet till a little distance behind it (ϕ''). Divergent rays fare yet worse, and do not meet until far below beyond the bottom of the eyeball. The only rays which would meet on the retina would be convergent ones, such as those indicated by dotted lines, which converge and tend to meet at *f* (hence the need of glasses to make the rays converge).

Now, since both the divergent and the parallel rays must be focussed at the same place (the bottom of the eye), it is clear that the apparatus must, in order to effect this, be accommodated. In order to deal with divergent rays (those from near objects), the lens must be made stronger, or, in other words, more convex. We have already stated that this is effected by a muscle which exists within the eye. When this muscle is at rest, the eye is adapted to receive and focus parallel rays from distant objects; when in action, it can focus divergent ones. Hence the feeling of effort and fatigue which often results from long looking at small objects.

It may possibly have occurred to some unusually attentive and intelligent reader, that we are involved in a little difficulty, in asserting that effort is needed for near objects. Do not, it may be asked, the parallel rays from a near object gain access to the pupil as well as the divergent ones; and if so, why cannot we use them without effort, just as we use them when at a distance, and when we receive them only? The explanation is, that the divergent rays which are received with them confuse the image. If they could be excluded, then the eye could use the parallel rays as well close as miles away. To be certain of this, try another simple experiment. With a fine needle prick the smallest possible hole in a card, and then try to read, looking through this hole, and putting the card and the page close to the eye. You will find that you can see letters through such a hole which are all blurred and indistinct without it; you can, in fact, read at an inch distance from your eye, whereas without it you cannot read at a shorter distance than eight inches.

The eye may be imperfect as an organ of vision without there being any actual disease, and merely on account of some peculiarity in its form, or peculiarity in its apparatus for accommodation. A great many persons are born with their eyeballs a little too long or too short, and hence great inconvenience in using them. It is only when the eyeball is exactly the proper length, that its use as an optical instrument—its adjustment, etc.—can be perfect. When it is of proper length, then the sharpness of sight will be found to be almost exactly the same in all persons. There are limits as to the size of objects which can be seen both in the distance and near, and these limits are about the same for all persons whilst the eye is in a state of health. We will now explain some of the common defects.

OVER-WORKED EYES. WEAK SIGHT.—We have proved that muscular effort is necessary to see near objects; the smaller and nearer, the greater the effort. Now the muscle of accommodation, although accustomed to long work, may yet under unusual stress tire and fail. When it does so, the eye becomes unable to see near at hand, and is compelled to rest. It is just as if you had been long standing on tip-toe to look over a wall; there comes a time when you can do it no longer. This over-fatigue is very common in some occupations: needle-women, engravers, printers, press-correctors, and the like, very frequently suffer from it. Indeed, the last-mentioned occupation, when pursued as it is by some, for twelve or sixteen hours a day regularly, almost always wears the eyes out sooner or later. In many cases the eyes will, however, bear without detriment an extraordinary amount of work.

We have compared the effort of looking long at small print, etc., to the effort of standing tip-toe; and, to follow the comparison, it is clear that the shorter the individual, the more fatiguing would be the effort of looking over a wall. Just so in the case of the eye: the shorter the eyeball, the greater the muscular effort necessary. Now, a very large number of persons have the eye from birth a little below its proper length. Such persons are obliged to employ the muscle of accommodation much more than others, and are very liable to suffer from its over-fatigue. They complain that they can see well for a little while, but cannot go on long. This symptom indicates the need for spectacles. It is only quite lately that it has been found out that this kind of weak sight results simply from the shortness of the eyeball. We owe the discovery to Professor Donders, of Utrecht, and, thanks to him, thousands now enjoy by the use of spectacles perfect sight, who formerly would have had to go through life with a constant and great deficiency. The prejudice against spectacles for young persons used to be very strong, but it is now happily disappearing. Now and then, even young children discover that they can see much better in their grandmothers' glasses; and when such is the case, spectacles ought always to be supplied. If they are not, the symptoms of weak sight and of overworked eyes are almost certain to be developed. For this condition, convex-glasses, "old sight," are needed. It is the opposite to short sight, and depends on the opposite condition of the eyeball.

SHORT SIGHT occurs when the eyeball is too long—egg-shaped instead of round. It is very common, and runs in families. The eyeball is usually too long from the time of birth, but it often increases in length subsequently. A person who is the subject of short sight, enjoys excellent vision for near objects; he has, in fact, a microscopic eye, and can "inspect a mite" in much more detail than another. He pays for this gain in one direction by a loss in another. He cannot see objects in the distance—cannot "comprehend the heavens."

Often, however, he will go through a large part of life rejoicing in his advantage, and quite unaware of his loss. Having no standard of comparison, he believes

FIG. 9.

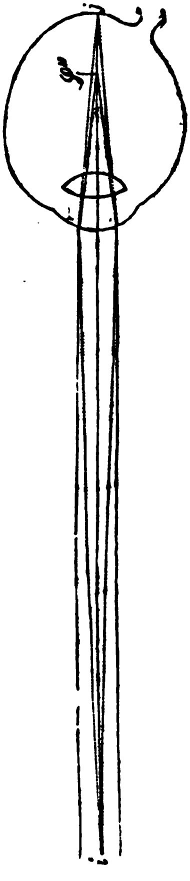


DIAGRAM OF AN EYEBALL MUCH TOO LONG (SHORT-SIGHTED).

(*From Donders.*)

Parallel rays (from a distance) meet in the eyeball (ϕ'') before reaching the retina, whilst strongly divergent ones (from a near object, as at *i*) meet in focus on the retina (*j*.)

that the manner in which he sees into the distance is the best attainable. An adult myope* who has never tried glasses is amazed, on using them for the first time, at the clearness with which he sees that which always before had been hazy and indefinite.

The reason that a long eyeball disables for distant vision is, that the lens of the eye being too forward, its focus is in front of the bottom of the eye, instead of exactly upon it. Thus, the eye can use divergent rays more easily than one of proper length, but cannot focus parallel ones at the proper place. This may be corrected by the use of a concave glass, which will make parallel rays diverge. Thus, myopes use spectacles of an opposite kind to those required by old persons, or by the weak sight which results from a too short globe.

Short-sighted persons acquire certain peculiarities of appearance. In the first place, their eyes often look full and prominent, and frequently have large pupils; next, from constantly trying to see better in the distance, they are apt to acquire a habit of "screwing" the eyelids; and, lastly, from the necessity of bringing the head near to the object observed, a certain degree of stoop is apt to be developed. These bad habits may, in many cases, be prevented by the use of proper spectacles. It is said that myopia even induces peculiarities of character, and that myopes are usually unsuspicious and easily pleased; being unable to observe many little matters in the demeanour or expression of those with whom they converse, which, being noticed by those of quicker sight, might induce feelings of distrust or annoyance.

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* The learned term for short sight is *myopia*. *Myopic* means short-sighted; and a *myope*, a short-sighted person.

There is an opinion widely prevalent, that short-sighted eyes are strong eyes, and wear well. Unfortunately, this is a mistake; for, in not a few cases, this condition is progressive, and ends in very serious failure of sight. It is quite true that, as a set-off for the fact that throughout life he has never been able to see clearly in the distance, the myope may in old age still retain his power of reading without glasses. In this sense, his eyes may last longer than those of his friends, but in no other.

Those who are short-sighted ought to observe a few simple rules in order to preserve their eyes. They should be careful to prefer large type for reading, and to hold the book up to the eyes, not bring the eyes down to the book. In writing, they should use a high desk, and on no account bend over a flat table. They should avoid, as far as may be, all close work, and relieve the eyes by frequent rests. Those who are short-sighted in but slight degrees may use spectacles or not, according to inclination; those who are so in a considerable degree will find safety as well as present advantage in their use; whilst those who have the defect in very high degrees must be cautious, and use glasses only under skilled advice. In all forms, if too strong glasses are used, they will increase the defect and irreparably damage the eyes. We have no wish to make a large class of myopes unduly anxious about the durability of their eyes. It is only in cases in which the sight gets shorter and shorter from year to year that alarm need be felt; then the necessity for rest is urgent.

Unfortunately, short sight occurs very frequently in those who are of a studious turn, and who are consequently very likely to increase it by their habits. It is an exception to what we said in the beginning as to the influence of civilization upon the prevalence of eye diseases. It is a defect to a large extent due to the pursuits introduced by the inventions of civilized life. It is rare amongst those who cannot read, and amongst those who follow out-of-door pursuits; and is believed to be more common amongst the studious Germans than amongst any other nation.

Although undoubtedly induced by occupation, it may be transmitted hereditarily.

OLD SIGHT *(presbyopia)*.—It is often thought that old sight is "long sight," and that it is in some sense opposite to short sight; but this is a mistake. Old people have no advantage over the young as regards sight in the distance; they have simply lost the power of seeing near objects well. It would be strange indeed if advancing age, which slowly but surely robs us of our various faculties, added anything to that of sight. It certainly does not. The impairment which ensues from age is the gradual loss of the power of accommodation. We have compared that power to the screw in an opera-glass, or to the movement of the tubes of a telescope one within the other. We might extend the comparison, and suppose that by constant use the screw has got worn, and will no longer act. Very gradual indeed is the commencement of old sight. About the age of thirty-five, without our noticing it, we begin to be less able to see small things near to us, and by the age of forty-five we have learned instinctively to keep the book an inch or two farther off than we did in youth. From this period onward to old age, the faculty fails steadily until we become quite unable to bring a book near enough to read from it. This loss occurs to all persons whose eyes were originally of proper length, and it is far more exactly proportionate to our years than is generally supposed.

Even when no longer able to read at all without glasses, the power of distant vision may be perfect. For this, no accommodation is wanted, and it is that power which alone has failed. The eye is itself perfectly healthy, but the lens substance has got harder and harder, and can no longer be altered in form, and thus made stronger when requisite. In some cases, however, the lens not only gets harder, but also somewhat flatter, and then its possessor will require spectacles both for distant and near objects, though he will be able to see distant objects with much weaker glasses than those which he uses for reading.

Old sight can always be remedied by spectacles, and it is most desirable that they should be used; they save the eye from fatigue, as well as improve its usefulness. The risk of using them too strong is not great, and the subject may be allowed to select for himself those that suit him best for reading. They ought to enable him to read easily at twelve inches' distance. It is a natural result from the slowly progressive character of the failure, that stronger and stronger glasses will be necessary as age advances. If the progress is rapid, and especially if glasses do not relieve it so much after a while as they did at first, then advice is needed.

You sometimes notice at church an old man with his spectacles on the tip of his nose, and his prayer-book held as far off as possible. These are sure signs that he wants stronger glasses. The effect of putting the spectacles farther from the eyes is to increase their power. The glasses used ought, however, to be strong enough to allow of their being kept close to the eyes, and it ought not to be necessary to hold the book more than a foot away.

CATARACT.—We now have to explain another very important and curious defect, which occurs chiefly in the aged. We have said, that as years advance, the lens gets harder; sometimes not only does it harden, but it changes from a state of transparency, like glass, to one of yellow haze, like amber or bees-wax, or even to a dense white, like spermaceti. When the lens has thus become opaque, a cataract is said to have formed. If you look at Fig. 5, you will easily see, from the position of the lens, exactly behind the pupil and in the centre of the eye, that it must, when opaque, prevent light from entering. Cataracts usually form slowly and without pain, and often take several years before they quite exclude the light. They are very common in the aged, as a mere result of age, and without any disease, and now and then they occur also in infants and in young persons.

The art of removing cataracts is one of the greatest triumphs of surgery, and is now the means of restoring sight to thousands who would otherwise be compelled to end their lives in darkness. In certain cases, in which the cataracts are said to be soft, the surgeon is content to stir them up with a needle, and leave them to dissolve; but in others, and the majority, he makes an incision in the eye, and takes the lens bodily out. After successful operations for cataract, the use of spectacles is always necessary, for one of the most important parts of the refracting apparatus has been removed, and must be replaced by a lens in front of the eye.

Formerly, surgeons used to "couch" for cataract; that is, instead of extracting the lens from the eye, they would, with a needle, displace it from the axis of vision, and leave it in the deeper parts of the eye. By looking again at Fig. 5, you will understand how this was practicable. It is a clumsy and imperfect procedure, and is now never thought of by scientific surgeons. I mention it chiefly in order to remark that now and then a cataract is displaced or couched, by accident—a blow or a violent shake, for example—or even without any assignable cause. In such cases the astonished subject is suddenly restored to sight. It is very possible that some of the supposed miracles of the middle ages may have been cases of this kind.

Surgeons meet with, after operations for cataract, very curious illustrations of the differences in human temper. Often the most grateful triumph will be displayed at the restoration of even a very limited share of sight; and now and then an old woman will grumble, after a brilliant success, because she "can't see well without spectacles."

In addition to the common defects which I have described, and which are of great interest to the non-professional reader as well as to the surgeon, the eye is liable to a great number of special diseases. A large group of these are seated in the deep parts of the organ, and cause more or less complete blindness without anything being visible externally. Such was the condition of Milton:—

> "These eyes, though clear
> To outward view of blemish or of spot,
> Bereft of light, their seeing have forgot."

To this group the term Amaurosis used to be given; and a witty writer defined it to mean cases in which the patient was blind and his surgeon could see no- The discoveries of modern science have, however, rendered this description no longer applicable. The surgeon can now examine the deep parts of the eye just as easily as those on the surface. This is done by a little instrument named the Ophthalmoscope. By its aid, and with artificial light properly arranged, the interior of the eyeball, its blood-vessels, the optic nerve, etc., can be readily seen, and any disease which may be present easily appreciated. It is not practicable here to describe either its use or its revelations. We may remark, however, that many of the details of the eye as seen by the ophthalmoscope are exceedingly beautiful and interesting, and that there is no reason why doctors should keep them to themselves. The instrument is as easily used as the microscope; and it is to be hoped that, before long, opportunities will be afforded to amateur physiologists, as well as to professionals, for enjoying the marvels which it displays. A countryman of our own, Mr. Cumming, made the earliest observations on the possibility of seeing into the living eye; but it was reserved for Helmholtz, Coccius, and Reute, of Germany, to invent and perfect the instrument which has, in a double sense, thrown such a flood of light on the obscure diseases of the eye. Their successful labours entitle them to high rank amongst the benefactors of mankind.

In reference to the diseases of the deep parts, we must say a few words respecting the ANATOMY OF THE RETINA, etc. By referring again to Fig. 5, the reader will see that the optic nerve enters the back of the eyeball, or rather it passes backwards out of the eye, and thence into the skull, to be joined to the brain. This nerve begins in the eye as a delicate outspread membrane, which lines the back of its cavity, and is in contact with the vitreous humour, which latter supports it, and holds it in place. The retina is indicated in Fig. 5 by a broken line. This retina is the structure which receives impressions. On it, as on a photographer's plate, images of objects seen are focussed by the lens apparatus in front. By means of the optic nerve (a bundle of nerve-fibres, or telegraph wires), the retina is made continuous with the brain; indeed, it may, in a certain sense, be regarded as a part of the brain drawn out of the skull, and packed within the eyeball to serve a special purpose. In structure, the retina consists of nerve fibres, and of a very delicate and complicated arrangement of minute nerve-cells. Close behind the retina is THE CHOROID, a membrane which supplies the back of the retina with blood, and which also, being loaded with black pigment, serves to absorb any superfluous light. In white rabbits, in albinoes, etc., there is no pigment in the choroid, and hence the red glare of their eyes, and hence, also, an inability to bear strong light. Outside the choroid we come to THE SCLEROTIC, the thick, strong, white membrane which gives form to the eyeball, and supports the whole of its marvellous internal mechanism.

IV.

THE SENSE OF SMELL.

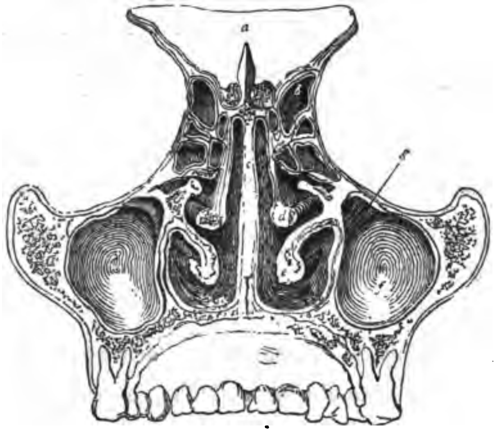
In our previous chapters we have been treating of those of our senses which minister specially to the mind. We come now to those which are connected more closely with the body; and we see at once a great distinction. For hearing and for seeing—at least, as we see and hear—we require not only nerves capable of being affected by the minute vibrations of light and the larger ones of sound, but also very intricate and complicated organs to receive these vibrations, and convey them to a not less complicated nervous structure. But the remaining senses are more simple. Wonderful as is the power of appreciating the variety of odours and of tastes that are presented to us, and vast as are the pleasure and advantage thence arising, we shall see that they are conferred by very simple means; and so may note that in Nature, as there is no grudging of resources, so also there is no waste. Nothing is done for show. The perfect beauty of the human form is the expression of work most perfectly, and in the simplest way, adapted for its end.

We will take first the faculty of smell. The place which this sense occupies is determined by its nature. It must be situated in the channel through which we breathe, inasmuch as the perception of odours is very largely dependent upon the passage of air over the nerve which is to be affected by them. We can imagine that the eyes, or at least the ears, might have been placed elsewhere without losing much of their usefulness,—indeed, if Professor Huxley is to be believed, some creatures have them in their tails,—but smelling must be seated in the nose. How tantalizing a delicious odour would be, if we could not sniff it up. This action is the equivalent of "looking," or "listening;" and, indeed, it may explain to us, by an easy example, what the real nature of looking or listening, or, in a wider sense, of *attending,* is. Besides the action of the mind, trying to perceive, there is, in all cases of attending to our bodily impressions, a bodily action also—an action of the muscles. We "sniff up" a faint sound by adjusting the tension of the drum, and in examining a minute object the eye "sniffs up" by contraction of the pupil and adjustment of the lens. In this respect, as in others, one law goes through all the senses.

Even if we did not smell at all, we must still have a nose to breathe through. For it may not be amiss to remark—being upon noses—that the habit of breathing through the mouth instead is a very bad one, and one that should never be tolerated, especially in children. Not that it should be combated by command or argument alone, though these are needful, still less by punishment. It never exists unless there is an impediment to the natural way of breathing, in the form, generally, of swelling of the lining of the nose or throat, and that impediment should of course be cured.

We ought to breathe, not through our mouths, but through our noses, not only because it is by this means alone that we can duly receive and enjoy the odours (when enjoyable) which accompany every breath, or take warning by them if the contrary, but because the nose is itself a natural respirator. It contains a special provision for warming and moistening the air inspired. Fig. 1, which represents a section of the nose from above downwards, illustrates this point. The reader is supposed to be looking from behind, and the section to be made about half-way between the tip of the nose and the ear. It will be seen that instead of being a simple channel, through which the air might pass unimpeded, it is cut up into a number of small and winding passages. It is, in fact, subdivided by various curved plates of bone, which project from each side towards the central partition, and leave at no part more than a comparatively

Fig. 1.



SECTION THROUGH THE NOSE FROM ABOVE DOWNWARDS.

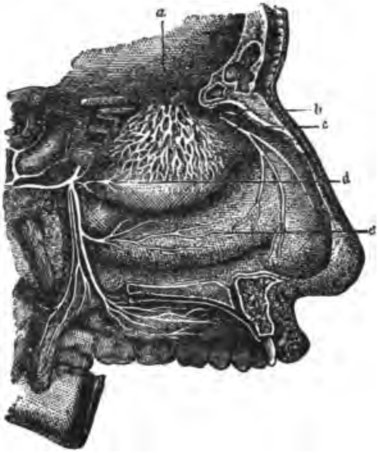
a. Bone of forehead. *b*. The frontal cells. *c*. Central partition, or septum, of the nose. *d*. The middle spongy bone. *e*. The inferior spongy bone. *f*. Cavity in the cheek bone. *g*. Communication of this cavity with the nose.

narrow space. Besides this, the nose communicates with large free spaces on each side and above, which are all of them filled with air. The spaces at the sides lie behind the projections called the "cheek bones," and the spaces above constitute the prominence, much larger in some persons than in others, just above the nose and between the eyes. Now these spaces have nothing to do with smell, neither indeed has all the lower part—much the larger part—of the nose itself. The large, curved, projecting bone (Fig. 1, *d*), called the lower *spongy bone*, and all the portion of the nose on a level with and below it, receive none of the nerves of smell. These are confined to the upper part of the cavity (see Fig 2). The lower two-thirds, nearly, of the nose, and all the adjoining cavities, serve to prepare the air for the purposes of breathing, and at the same time fit it to act more powerfully in exciting the sense of smell.

For this purpose these parts are covered with a thick layer of membrane which, especially in the neighbourhood of the spongy bone, receives a very large supply of blood. (Thus it is that the nose bleeds so freely and so frequently.) This membrane secretes the mucus with which the nose is moistened, and it thus serves at once to warm and to moisten the air which is inhaled, and which must pass over this surface before it can reach either the lungs or the upper portion of the nose appropriated to the sense of smell. The tears, also, which are continually washing the surface of the eye (see page 65), pass down into this portion of the nose, and so help to maintain its moisture. During "colds" these secretions are sometimes enormously increased. The cells which line the lower part of the nose—as in many other parts of the body—are provided with what are termed *cilia*—minute hair-like processes, which during life, and indeed for a short time after death, are in a state of rapid motion to and fro. Thus regular currents are maintained in any fluids that may be present. In the upper part of the nose, where smell is performed, the cells do not posses cilia, and the membrane is still softer and thicker, affording a bed for a special nervous structure.

This nervous structure is represented in Fig. 2, which shows the olfactory nerve (as the nerve of smell is termed) as it is distributed on the outer side of each nostril. It is distributed also in a similar way upon each side of the central partition. These nerves come off on each side, from a bulb of nervous matter (Fig. 2, *b*), which consists of small cells like the grey matter of the brain, and which is connected with the brain by a short stem. The bulbs lie within the skull, immediately above the nose, and the nerves pass into the nostrils through some twenty or more small orifices in the bone; which accordingly, when it is dry, looks somewhat like a sieve at this part, and is called the "sieve-like plate." Passing through the perforated plate of bone, the nerves form a close network on both sides, and on the roof of the narrow upper portion of the nose (see Fig. 1). Besides these special nerves of smell, the interior of the nose is supplied with nerves which give it ordinary sensation, and which are parts of the same nerve that gives sensation to the face, the eyes, the teeth.

Fig. 2.

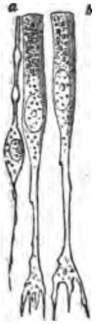


THE DISTRIBUTION OF THE NERVE OF SMELL IN THE OUTER WALL OF THE NOSE.

a. The bulb of the olfactory nerve. *b*. Its branches. *c*. and *d*. Branches of a nerve of ordinary sensation. *e*. Distribution of these on the lower spongy bone. Below are seen the upper and part of the lower jaw.

The nerve of smell is different in its character from the other nerves, being very soft, and not having a distinct outer part, or sheath, and internal "axis."* It is unlike any other nerve also—so far as is yet known—in this, that it passes to the very surface of the body, its fibres at their termination being entirely uncovered. The cells which clothe the mucous membrane on which it is distributed are of what is called the columnar form (see Fig. 3, *a*). And lying side by side with them are found minute rods or cylin-

FIG. 3.



TWO OF THE CELLS WHICH COVER THE MEMBRANE OF THE NOSE, WITH ONE OF THE TERMINATIONS OF THE NERVE OF SMELL.

a. nerve. *b.* cells. Magnified 500 diameters. (*After Schultze.*)

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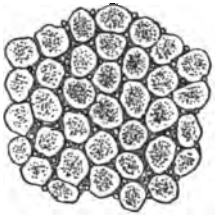
* It has been doubted by some whether this nerve really is the organ of smell, but into this controversy we need not enter. One of the strongest arguments for its being so is, that it is more developed in animals in proportion as their sense of smell is strong.

ders, with cell-like expansions about midway in their length, which there is good reason for believing to be the ends of the olfactory nerves (see Fig. 3, *b*). These nervous rods or cylinders are very numerous, so as to surround the cells of the mucous membrane (see Fig. 4), and they terminate on the same level with them, so that they come into direct contact with the air and whatever odorous substance it may convey, except in so far as they are guarded by the mucous fluid that bathes the whole surface. This fluid it is the function of numerous small glands (little bags lined with small cells), embedded in the soft and pulpy membrane, to secrete (see Fig. 5, *d*).

FIG. 4.



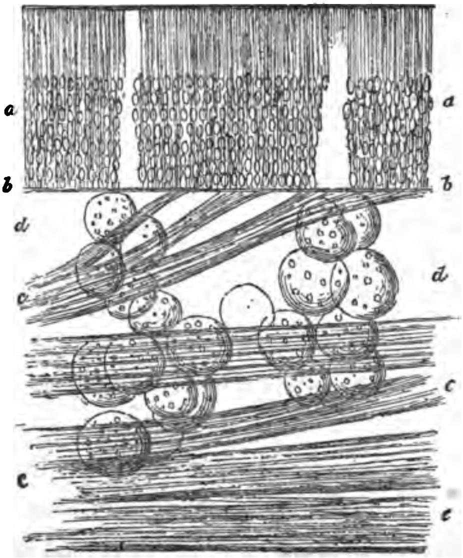
SURFACE OF THE MEMBRANE OF THE NOSE (MAGNIFIED 500 DIAMETERS).

The large spaces are the ends of the cells. The ends of the nerves are the small white points around them. From the horse. (*After Schultze.*)

This is the simple arrangement of parts on which the sense of smell depends.

The external form of the organ which contains them is too well known to need description. But it may be mentioned that the outward nose is made up of two portions: an upper, rigid, and consisting of thin plates of bone; and a lower, movable, and composed of several distinct portions of cartilage or gristle, which are acted on by four small muscles on each side. Thus the nose

FIG. 5.



SECTION OF THE MEMBRANE LINING THE NOSE.

a. Layer of cells. *b.* Boundary between the cells and the membrane beneath. *c.* The nerve of smell. *d.* Small glands. Magnified 200 diameters. (*After Schultze.*)

is able, by its motions, not only to take its due part in the expression of the countenance, but also to assist in respiration, as we may well see in the flushed face of a child who has run himself out of breath, and often—but too often—on sad sick-beds, in the pale and livid countenance of suffocating men. The opening of the nostrils is lined with small hairs, which serve as some protection against the intrusion of foreign bodies floating in the air, and they lead into the upper and back part of the throat by three partially distinct passages, called the upper, middle, and lower meatus of the nose, which are separated from each other by the lower and middle spongy bones (see Fig. 2).

The sense of smell is very widely distributed among animals, in many of which the olfactory nerves are much larger than in man; and even when no olfactory nerve can be found, the possession of smell is often proved by actions. Its chief use appears to be to aid in the choice and discovery of food, and it might be expected, therefore, to be more acute in many classes of animals, such as the beasts of prey, than in ourselves, who are in this respect less dependent on it. The development of this sense in dogs is very remarkable; and not less so is the peculiar direction it appears to receive in different species, which is probably not wholly due to training, each having as it were its own natural prey. And the chemist, who has to trace out the poisoner, often, like the bloodhound, hunts him down by smell; in many cases distinguishing by their odours the different forms of poison better than by any other means. But perhaps the most remarkable development of the sense of smell is found in the insect tribe; and Dr. Hicks has recently shown that a large nerve, which goes to the posterior pair of wings in four-winged insects, or the corresponding nerve in those that have only two (as the house-fly), is the nerve of smell. In many classes of insects this nerve is larger or smaller, as the eyes are less or more perfect: it is very small, for instance, in those which pursue their prey by sight, as the dragon-flies, the eyes of which are so conspicuously large. In moths, like the silk-worm moth, the sense of smell appears to be carried to the highest pitch, and to have its chief use in match-making.

But even in man, the sense of smell is sometimes very acute. There are persons who can distinguish the presence of a cat through several doors. And, like all our senses, it is susceptible of great development by exercise. The savage smells almost like the dog; and persons unhappily deprived of other senses have sometimes found in this lowly faculty no inconsiderable compensation. It is recorded of James Mitchell, who was born blind and deaf, that he could distinguish persons and recognise strangers by the sense of smell. Humboldt states that the Peruvian Indians can distinguish by it, in the dark, persons of different races.

A distinction must be made between odours, properly so called, and other sensations which the nose shares in common with the rest of the surface, such as that of the heat of mustard or the pungency of hartshorn. These we do not smell, but feel,—and we feel them with peculiar acuteness in the nose, because there the sensitive nerve has a very thin covering. This feeling of hot or pungent bodies may remain when the sense of smell is entirely lost,—a loss which not very unfrequently occurs, either from the effect of often-repeated "colds," or from disorder of the nerves. It is happily not a very serious inconvenience, the chief disadvantage being the absence of protection against hurtful vapours, which often betray themselves by their fetor. In some cases, in which the sense of smell has been lost, the presence of ill odours could still be recognised by a tendency to increased secretion of saliva which they produced. On the other hand, persons who have never possessed this sense at all (and some are born without it) may pass a long life and never discover its absence. If, however, it has been once possessed, its loss is felt as a great privation. One of our most gifted authors thus afflicted, describes in touching language, the exquisite delight which the sudden perception, though but for a moment, of the odour of a field of beans in full bloom afforded.

Nor, indeed, should we be at all in the right if we despised the sense of smell as a trifling possession, or even if we estimated its value—however highly we might place it on these grounds—by the mere bodily advantages or pleasures it secures. Though ranking behind sight and hearing, smell also is a faculty with spiritual relations. These are manifested in various ways. Perhaps one of the most interesting is the strange power which sensations of odour have of awakening memory, and recalling with extraordinary vividness long past and forgotten scenes. Tennyson refers to this power in his "Dream of Fair Women":—

> "The smell of violets, hidden in the green,
> Poured back into my empty soul and frame
> The times when I remember to have been
> Joyful and free from blame."

And very many of us, who are not poets, have had the days of childhood in all their innocence flashed back upon us with the freshness of reality by some sudden odour, which has brought at once tears to our eyes and purer thoughts to our hearts.

Whether it was from associations of this kind, or from some feelings connected with odours that the distractions of later days have lost us, perhaps we cannot now discover, but that the early world felt a sacredness in odours of which we have lost the consciousness, seems beyond question. Through all antiquity not a temple was erected to any god that did not smoke with continual offerings of frankincense and all sweet perfumes. The same feeling, that fragrance was the best and highest of all gifts, extended itself into private life; and if any man would receive a guest with special honour, or testify the utterest grief and love for a departed friend, he lavished upon him the richest spices and the costliest perfumes. And though much of pride and luxury in private life, and much of gross superstition in religion, mingled with and defiled these usages, yet that they were not devoid of a genuine foundation many passages of Scripture may teach us. The Jews were commanded to offer sacrifices of sweet smells, and a special altar to burn incense upon was directed to be made of shittim-wood, overlaid with gold. Nor is the meaning of these sweet-smelling sacrifices left doubtful. They were the types of praise and prayer; the ascending smoke represented the sighs, the songs, of the assembled congregation; it wafted visibly to heaven the groanings that could not be uttered, the gratitude too deep for words. What passionate longings, crushed into the deepest recesses of the heart, where no human eye could see them; what secret bursts of exultation and delight, have poured themselves out, have found themselves written large and full—yet unbetrayed—in those fragrant wreaths that filled the Temple, acceptable to Him who filleth heaven and earth:—crowned by the passion of that heart which broke in fragrance on the Saviour's feet! And still, in highest heaven, the prayers of the saints are as vials full of odour; these prayers, wrung from our hearts by fierce sorrows, by terrible temptations, by consciousness of weakness, by sense of sin; these are the sweet odours unto Him. They are made sweet by sympathy, by knowledge of the triumph they foretell.

To us in this aspect odours are as nothing. They have sunk, even, almost into an undeserved contempt, as the very types of luxury. It is interesting to inquire why this should be. The difference has been ascribed to a greater sensitiveness to odours on the part of the early and Eastern nations, together with the greater abundance of perfumes in the warmer climates they inhabited, and the need they felt for bathing, with subsequent anointing. But we do not think these are the true reasons, though they may have had some share in bringing about the change. To us it appears that a truer and more powerful cause is to be found in the gradual development of music. The ear, in short, has supplanted the nose. It is in sound, and not in scent, that the emotions of the modern world find their expression. Though musical instruments were in use from the earliest periods, the ancients could hardly be said to have had, *in our sense of the word,* any music; and when we consider what that is to us and does for us, we can hardly fail to see that, if our fathers really were of like passions with ourselves, they must have needed something to supply its place. This their use of odours evidently did. They employed them in public places, bestowed them on their friends at their entertainments, made them part of every public ceremonial; all which we do with music. Above all, they made perfumes a chief element in their religious services; but with us music has emphatically taken this place. It weeps and exults and aspires for us; it teaches our languid hearts to feel; and while it lifts our very souls to heaven, we cannot miss the wreaths of odorous smoke that performed the same service for the men of old.

It is no argument against this view that some earnest religious bodies repudiate music except in its simplest forms, and that those churches which make most use of music, as the Greek and Roman, also still use incense to a slight extent. More than one cause, doubtless, has been at work, but the fact of the substitution of sound for odour is manifest, and indeed the change is a natural one; the affinity of the two senses is especially close, and the sweet scents prepared by nature may well have been the forerunners to untutored man of the sweet sounds the cunning brain and fingers of his maturer days should develop for himself. In "Twelfth Night," Shakspeare makes the duke say of music,—

> "That strain again: it had a dying fall;
> Oh it came o'er my ear like the sweet south,
> That breathes upon a bank of violets,
> Stealing and giving odour."

So, again, Lord Bacon, in his essay "Of Gardens," says, "The breath of flowers is far sweeter in the air—*where it comes and goes like the warbling of music*—than in the hand." These two passages alone might suffice to make us feel that in its deeper meaning perfume is one with music.

In substituting the latter for the former, doubtless, we are largely gainers on the whole. The ear is an organ of far greater capacity for spiritual purposes than the nose; but the gain may not be altogether on our side. We may concede that we have lost something through that more frigid temperament and less genial clime which have degraded the sense of smell into a mere matter of bodily pleasure, and sanitary or scientific use. But on the whole it is a gain. If the musical faculty could only be fully developed at the expense of the sense of smell, it was well the latter should be sacrificed; well, too, that in these days, when there is so much work for it to perform in making and keeping our cities wholesome, the nose should not be diverted from its proper work, in which it is unsurpassable, to romantic enterprises and toils of imagination, for which it is less fitted. The nose is a working organ after all, and loses no real dignity in resigning to the ear the function of rousing and expressing feeling.

On this point the late and much-to-be-lamented George Wilson has some remarks so excellent, that we cannot forbear quoting them.

"I have not seen it anywhere laid down as a general rule, but I believe it might be affirmed, that we are intended to be impressed only sparingly and transiently by odour. There is a provision for this in the fact that all odours are vapours or gases, or otherwise volatile substances, so that they touch but the inside of the nostril and then pass away.

"In conformity with this fleeting character of odorous bodies, it is a law in reference to ourselves, to which as far as I know, there is no exception, that there is not any substance having a powerful smell of which it is safe to take much internally. The most familiar poisonous vegetables, such as the poppy, hemlock, henbane, monk's-hood, and the plants containing prussic acid, have all a strong and peculiar smell. Nitric, muriatic, acetic, and other corrosive acids, have characteristic potent odours, and all are poisons. Even bodies with agreeable odours, like oil of roses, or cinnamon, or lavender, are wholesome only in very small quantities; and when the odour is repulsive, only in the smallest quantities. Without accordingly enlarging on a topic which might be unwelcome to many, it may be sufficient to say here, that, so far as health is concerned, the nostrils should be but sparingly gratified with pleasing odours, or distressed by ungrateful ones. No greater mistake can be made in sick rooms than dealing largely in aromatic vinegar, eau de cologne, lavender water, and other perfumes. This hiding of one odour by another, is like trying to put away the taste of bitter aloes by that of Epsom salts. Physical comfort is best secured by rarely permitting an infraction of the rule, that the condition of health is no odour at all.

"Turning from this lowest and least attractive aspect of the sense of smell to one which acquires a higher importance from the moral considerations which, in some respects, it involves, it is of interest to notice how much longer we tolerate a forbidding odour than we continue to relish a grateful one.

"Perfumes quickly pall upon us, and we loathe the concentrated essences of even the sweetest flowers. But, in their daily calling, men submit without murmur to the most repulsive effluvia, and work even cheerfully amidst noisome gases. In the one case we seek pleasure, and are disappointed, because the nerves of smell, dulled by the first impression upon them, cannot with equal sensitiveness respond to a second. In the other, for the same reason, we can suffer without discomfort the diminished sharpness of the irritation, whose sharpest provocations are its first. There is thus a physical reason why we should tire of a smell once pleasant, and grow indifferent to a smell once unwelcome. There is a moral reason also. For in the one case we think of pleasure, and in the other of duty. The palled perfume tells us that but little of our lives may be spent in merely pleasing our senses. The tolerated infection bids us sit by the sick man's side, and set the preciousness of his life over against a little discomfort to ourselves. And so it is that, while the listless voluptuary flings away the rose which has become scentless to him, the metal-worker labours heartily among the vapours from his crucibles and refining vessels, and the bleacher inhales without a murmur the fumes of his chlorine; while, most tried of all, the busy anatomist asks no one for pity, but forgets the noisome odours about him, in delight at the exquisite structures which he is tracing, and the heroic physician thinks only of the lives he can save."*

Nothing is more wonderful in respect to the sense of smell than the minuteness of the substances which are capable of affecting it. One part of musk in thirteen millions of air can be detected. Whether odorous substances give off minute particles which reach the nostrils, or whether smell may be excited by a motion caused by them, like that of heat or light, is not certainly decided; but probably both occur. Many odorous bodies, such as camphor, perform peculiar motions when small portions are placed on water; and Professor Tomlinson found that these were due to the rapid giving off of minute particles which form a film on the water. But the most interesting experiments on odorous bodies are those described by Professor Tyndall, in his recent volume on "Heat considered as a Mode of Motion." He finds that the minute atoms of which all gases consist, must be regarded as being in a state of motion, each one tending to fly off from the rest in a straight line; an odorous vapour fills a room so rapidly by virtue of this tendency of all its atoms, and it would fill it much more quickly except that these atoms as they fly strike against and are hindered by the atoms of the air. But again, he finds, that odorous exhalations absorb a vast amount of heat. "No chemist," he says, "ever weighed the perfume of a rose; but in radiant heat we have a test more refined than the chemist's balance. The quantity of hartshorn removed from a bottle by a single act of smelling, exercises more action on radiant heat than all the air contained in a large room. By testing various perfumes, Professor Tyndall found that that of the geranium absorbed thirty-three times as much heat as air, while that of aniseed absorbed three hundred and seventy-two times as much.

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* *The Five Gateways of Knowledge*, p. 61.

This fact indicates that odorous substances are in a state highly prone to active change; and Professor Graham has pointed out that, generally speaking, they are substances which are prone to unite with oxygen. Nor can we smell unless the odorous body is accompanied by a stream of air.

We may be sure of one thing: that if the nose had not sunk down into a very degraded rank, it would never have been made a snuff-box. But however much a naturally refined and delicate organ may be thus perverted, perhaps it can hardly be affirmed that the moderate use of snuff does any special harm. It is, however, a matter worth considering, now that there is so much evidence that excessive smoking injures the sight, whether the application of tobacco to a region so closely connected with the eyes may not tend to injure them. But besides snuff-taking, which may itself be considered a disease, the nose is not subject to many morbid conditions. The small glands which cover it sometimes become obstructed with their own secretion, and give it a spotted appearance. Of this condition we shall speak when we treat of the skin. It becomes red from over-living, and from under-living likewise; because in each case the circulation of the blood is disordered.

When the nose is very prone to bleed, and cannot be arrested by door-keys down the back, or by cold water freely applied, the best plan is to let the child stand with his arms raised. He should be well supported, and should be kept in this position until the bleeding ceases, which it does when he becomes faint. But nose-bleeding is in some cases so serious an affair, as to demand for its treatment the utmost surgical skill. When the nostrils are obstructed by thickening of their lining membrane, which is indicated by the mouth being kept partly open, by snoring, by a choky sound of voice, or when the breath coming from the nostrils is offensive, general medical treatment is required, including plenty of air, exercise, and good food, and guarding from draughts and damp; but, in the meantime, it is a most useful plan to draw up, quite through the nose into the throat, a little water, to half-a-pint of which a teaspoonful of salt has been added, and thus to wash the passage. In not a few cases, however, obstruction to the breathing through the nostrils arises from soft pulpy growths, which are the better for prompt attention.

V.

THE SENSE OF TASTE.

TASTE appears to stand midway between the sense of smell and that of touch. It is closely allied in its use, and in the nature of the sensations it gives, to smell; from which it is, indeed, sometimes almost indistinguishable. But in the character of the organs on which it depends it more resembles touch, and this in two respects: first, that we can only taste substances which are in contact with our own body; and, secondly, that the nerves by which we taste are not, like those of sight, of hearing, and of smell, capable of that one office alone, but are ordinary nerves which can discern general sensations—as those of pleasure or pain, or heat or cold, or touch, besides.

Thus, as we descend in the rank of the senses, we find less and less that is special. In the eye and ear we have a special nerve and a special mechanism to receive the impression as well; in smell there is no special mechanism, a part of the general mucous surface of the body suffices to receive the impression of odours, but there is a special nerve; in taste, there is neither a special nerve nor a special mechanism.

For though the tongue is the chief organ of taste we must not think of it as being the only organ, or as existing even chiefly for that end. As the nose exists rather for breathing than for smelling, so the tongue is, in truth, more an organ of touch than of taste; it exists rather as a means of grasping than of enjoying food, and might, perhaps, best be regarded as a kind of third or subsidiary hand; as we see when we look at its use in many of the lower animals.

In the shell-fish and the like—to begin with the lowest creatures that have tongues—this organ bears their teeth, and serves, not to taste, but to masticate. In many fishes, too, the tongue bears teeth, whereby they grasp their prey; some others having no tongue at all.

Among reptiles, the frog catches flies between the two portions into which the tongue is divided, as between the limbs of a forceps; and the chameleon uses its tongue in the same way, darting it out to a length exceeding that of its whole body, and entangling insects by means of a viscid secretion with which its club-shaped extremity is covered.

In birds, the tongue is usually horny at the tip, though there are some exceptions, of which the parrot is one. Its hand-use is seen in many instances; in the humming-bird it is rolled into a sucking-tube, and terminates in hair-like filaments for retaining the nectar of flowers; in the toucan (a bird of the parrot tribe) it is fringed with bristly processes for trying the ripeness of fruit; and in the woodpeckers it is barbed with sharp spines for seizing insects.

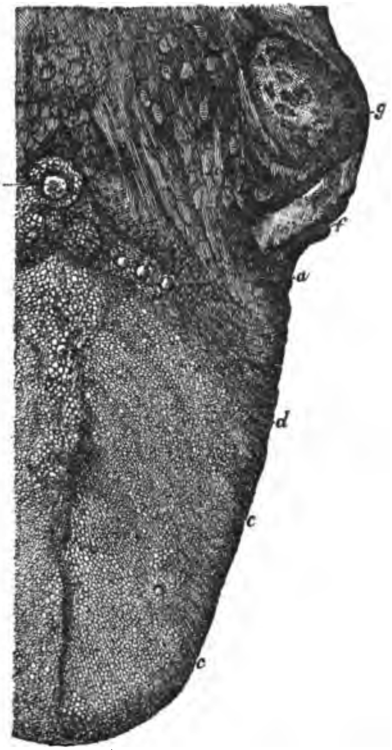
Among mammalia, we may mention the tongue of the anteater, which resembles somewhat that of the chameleon, and in seizing its natural food is protruded sixteen or eighteen inches. Some bats, again, possess in their tongue a perfect sucking organ; and who has not noticed how the horse lays hold of the grass with his tongue? In the flesh-eaters (the Carnivora), that organ is armed with horny recurved spines, which aid in grasping their food, or in rasping the flesh from the bones, not to speak of its use in cleaning their own coats. Of those four-handed creatures, the monkeys, we will not speak; no doubt they—making, as they do, a fifth hand of their tails—find little need for a hand-function in their tongues. But even in ourselves, it is noteworthy, that, so far as regards delicacy of sensation, the tongue is still the most highly endowed organ of touch, and can distinguish many minute forms with greater exactitude than the best trained fingers.

In short, taste is a secondary function of the tongue, and is by no means exclusively confined to that organ. The upper and back part of the mouth is also endowed with this sense, and so, it would appear, from some recent experiments of Professor Syme, is the upper portion of the throat, still more highly. Having had occasion to remove the whole tongue of a man, Mr. Syme found that his patient could still distinguish different articles by their taste, but only when they passed into the pharynx in the process of swallowing. From this it would appear that the act of swallowing is essential to a full perception of taste. And the Professor well remarks, "If the pleasure of taste could be perfectly gratified by mastication without deglutition, there would be no limit to the consumption of food; but the instinctive desire to swallow an agreeable morsel, affords a check to any such abuse."

We may add, that, although no doubt very naughty, children are perhaps not quite so unreasonable as is supposed in refusing to swallow nasty medicines, when they have taken them into their mouths.

Still taste resides chiefly in the tongue, both by virtue of the fuller distribution there of the nerves of taste, and also because the tongue is able, by its motions, to roll sapid bodies between itself and the walls of the mouth, by which means their flavour is greatly increased. For the sense of taste appears to depend upon the substance tasted being dissolved, and its solution penetrating through the minute cells which cover the tongue (as they cover all the rest of the internal surfaces of the body), and coming into contact with the nerves which lie beneath them. This, of course, is greatly aided by the

FIG. 1.



SURFACE OF THE TONGUE, SHOWING THE PAPILLÆ.

A little more than half is given.

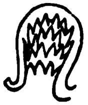
a. The circumvallate papillæ. *b.* A larger papilla, situated in the centre and back part, and called the *foramen cæcum.* *c.* Fungiform papillæ. *d.* Filiform and conical papillæ. *f.* Glands of the fauces. *g.* Tonsil.

motions of the tongue, and by the pressure which it applies.

The appearance of the surface of the tongue is represented in Fig. 1. It will be seen that it is covered with small elevations, and that these are of various kinds. In fact, the tongue bears on its surface no less than four different kinds of organs, if we may give them that name, of which one kind serves chiefly the sense of touch, another renders it more useful as a means of grasping objects, and two kinds serve the sense of taste. These organs are all termed *papillæ,* because they consist in more or less pointed elevations of the covering membrane, into which there pass minute blood-vessels and nerves.

The first kind of papillæ, those which make the tongue so sensitive an organ of touch, are the smallest and most numerous. They are minute, sharp processes, very much like the papillæ which are found in the skin, and are closely studded all over the tongue, and even upon the

FIG. 2.

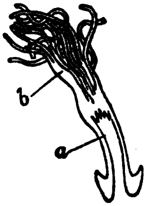


THE SMALL PAPILLÆ ON THE SURFACE OF ONE OF THE (FUNGIFORM) PAPILLÆ OF TASTE.

surface of the larger papillæ: Figs. 2 and 4 exhibit them covering the papillæ of taste.

The second kind of papillæ, those which enable the tongue to grasp, are less developed in man than in many other animals; they are called *filiform* (or thread-like), and are seen very much magnified in Fig. 3. The layer of cells which covers them (as it covers all the other papillæ) is prolonged into thin processes somewhat resembling hairs. They are set, for the most part, with a slight inclination backwards. In the carnivora these papillæ are very large, and the hair-like processes are often of a horny consistence. These are closely set over the anterior three-fourths of the tongue, especially along the central part. They become shorter at the sides and tip, and are arranged in slanting ridges, which gradually disappear as they reach the edge.

Fig. 3.

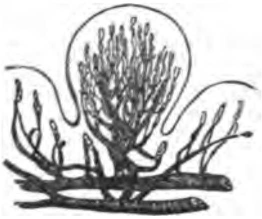


ONE OF THE FILIFORM PAPILLÆ.

a. The papilla terminating in small secondary papillæ. *b.* The hair-like processes covering the papilla.

The papillæ which serve taste are the largest, but one kind much larger than the other. The smaller of the two are called *fungiform*, because they are larger at the upper part than at the base—like a small mushroom or *fungus* (see Figs. 2 and 4). They are less numerous than the thread-like papillæ of which we have spoken, but still are scattered in large numbers over the tongue, being more numerous at the sides than about the centre. They are of a deep-red colour, from their large supply of blood, and the layer of cells that covers them is thin and soft.

Fig. 4.

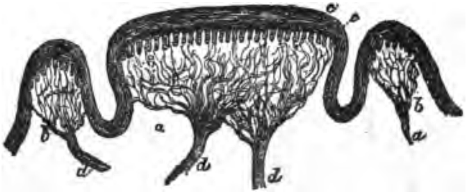


SECTION OF A FUNGIFORM PAPILLA.

Showing the blood-vessels entering it; at the sides are shown the single loops of vessels which pass into the small papillæ around.

The largest kind of papillæ are found only at the back of the tongue (see Figs. 1 and 5). They are called *circumvallate* ("walled-around") because they consist of a central elevation surrounded by a depression, around which, again, there runs a slight elevated rim. Thus they resemble somewhat a citadel surrounded by a trench and by an external mound, both citadel and mound receiving blood-vessels and nerves. These circumvallate papillæ are only from ten to fifteen in number, and are arranged quite at the back part of the tongue, in a form resembling the letter V, but with a less sharp angle (see Fig. 1, *a*). In these papillæ the nerves are especially large.

FIG. 5.

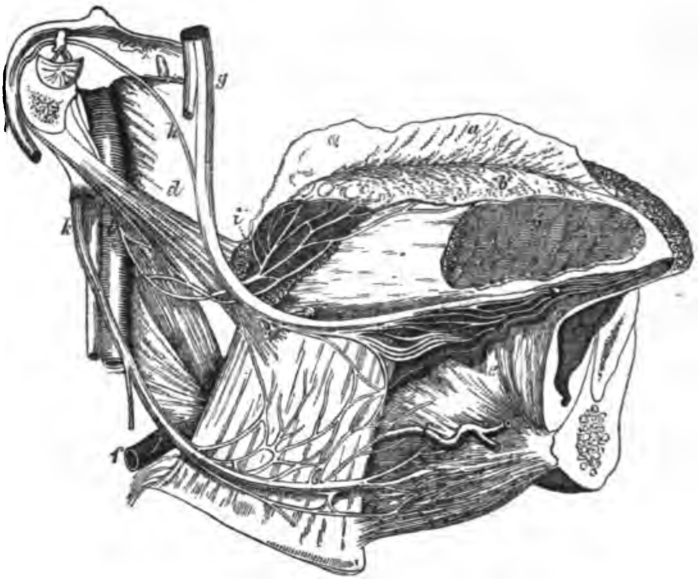


VERTICAL SECTION OF A CIRCUMVALLATE PAPILLA.

a. The papilla. *b*. The surrounding wall. *c*. Layer of cells covering them. *d*. Nerves. *e*. The smaller papillæ, which, when found upon the larger or taste-papillæ, are called *secondary*.

It thus appears that there are two modes, slightly differing, in which the nerves of taste are, as it were, "housed" at the surface of the tongue. Curiously enough, there are also two distinct nerves, which are distributed—at least in chief part—one to the *fungiform* papillæ at the front and sides, and the other to the *circumvallate* papillæ at the back. These two nerves are seen in Fig. 6, at *g* and *i*.

FIG. 6.



A SIDE VIEW OF THE TONGUE.

Showing its nerves and some of its muscles.

a. The cellular covering of the tongue partially raised. *b*. The papillæ exposed. *c*. The circumvallate papillæ. *d*. A muscle passing from the throat to the tongue. *e*. The muscle which radiates from the inside of the chin to the tongue. *f*. The artery of the tongue. *g*. Nerve of the anterior part of the tongue. *g'*. Its distribution. *h*. Nerve passing to join it through the ear. *i*. Nerve of the posterior part of the tongue. *i'*. Its distribution. *k*. Motor nerve of the tongue, supplying its muscles.

Still more curiously, it seems also to be the case that different kinds of flavours are perceived by these two nerves respectively; salt and acid substances being tasted chiefly at the fore part of the tongue, and bitter ones chiefly at the back. Experiments on animals also, have confirmed this fact: a dog in which the nerve of the posterior part of the tongue has been divided, will take quinine mixed with its food, but will not take acids; one in which the nerve of the anterior part has been divided, will take acids, but not quinine.

And as pressure on the eye produces a sensation of light, and pressure on the ear one of sound, so also in the tongue various influences call forth its special sensation of taste, and this taste differs according to the part which is affected. Thus touching the tongue near its root with a glass rod, or placing a drop of water there, produces, at least in some persons, a distinct bitter taste.

On the other hand, a current of air or a stream of electricity directed to the front part causes a salt taste. It was, indeed, by means of this salt taste generated in the tongue by an electric current, that Volta's attention was directed to the production of electricity by the contact of metals, and hence the whole science of galvanism arose; showing, as Mr. Lewes well says, that "nothing is trivial except to trivial minds, and to trivial minds nothing is important unless it directly concerns their interests."

Professor Graham has lately pointed out a distinction between substances, which consists in their being capable or not capable of passing, when in solution, through thin membranes.* Soluble bodies which are crystalline, for the most part pass readily; those which are of a jelly-like consistence do not pass. Hence, a division is made into crystalloids and colloids—crystal-like and jelly-like bodies.

Now, as might be expected, it is the crystalloid class of bodies, those which readily pass through membranes, that possess taste. And of these, acids and bitters appear to be most readily detected by the tongue, then saline substances, and lastly sweet ones. Of quinine one part can be tasted in 33,000 of water, of sulphuric acid one part in 10,000, of common salt one part in 200, and of sugar there is needed one part in 80. If the tongue be immersed for a short time in water made cold by being mixed with ice, or at a temperature as high as 125°, the sense of taste is in a great measure lost.

There is one exception to the necessity of a moist state of the tongue for the perception of tastes, and that is in the case of gases, which are only tasted when it is dry. Thus carbonic acid, which in water is tasteless, gives a sweetish acid flavour if directed in a stream upon the tongue after it has been dried.

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* To this process he gives the name of *dialysis*.

Taste is, perhaps, almost the soonest exhausted of the senses, as it is reasonable that it should be, having no purpose to serve when appetite is satisfied. It is also —though capable of great cultivation, as in the case of tea-tasters—one of the least discriminating. If port and sherry be alternately tasted by a man whose eyes are kept shut, he soon becomes unable to distinguish one from the other. This is probably due in some degree to the particles of each remaining a certain time in contact with the nerves. Besides, just as secondary colours are seen of a contrary kind, after the vivid impression of a very bright one, so there are secondary tastes, or "after-tastes" as they are called; some bitter substances, such as tannin, being followed by a sensation of sweetness. And one taste also may destroy another, or at least may dull the perception of a hot and pungent body. If it is masticated with a large quantity of salt, the pod of the red pepper may be eaten without burning the tongue.

Thus we may see that the art of the cook demands no contemptible skill so to mingle flavours as to bring out the full power of each, and so to cause them to succeed each other as that each may add a relish to the next.* And though nothing is more contemptible, and few things more degrading, than to be a slave to the pleasures of the table, it yet behoves us gratefully to recognise the goodness that has surrounded the necessary act of taking food with enjoyments which, if moderately used and made the means of cultivating the social affections, are not without their elevating influences. And it should never be forgotten, especially by those who have the management of children, that the pleasantness of the taste of food is a very important element in its value. No mistake could be greater than to suppose that our pleasures are squandered—are wasted on us with no other result, though that is no mean one, than our enjoyment. Every one of them, in its due place, is a potent influence for good, even on our bodily frames. The thrill of natural delight that runs through a sensitive nerve imparts a fresh vigour to every function. But the delight must be a natural one; the over-stimulation of the sense of pleasure exhausts as much as its natural gratification refreshes.

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* In Russia, dinners sometimes begin with toasted cheese, and apparently with good effect. Perhaps, acting as a strong stimulus to the papillæ, it increases their sensibility.

And this law of the usefulness of natural pleasure is strikingly exemplified in the sense of taste. The food that is enjoyed is the food that is digested. The pleasure of eating is an essential factor in the due appropriation of the meal. In the first place, the savour of the food is the natural stimulus to the glands which secrete the saliva, and causes this fluid, which plays a very important part in digestion, to be poured forth in due quantity.* And there can be little doubt that the pleasurable sensations of taste have a similar influence upon the stomach, besides the general improvement of digestive tone which they induce.

It is important for health that the food should be enjoyed, and therefore that within the bounds of strict moderation it should be such as can be enjoyed. This should be especially remembered in the case of invalids, the whole course of whose diseases may depend upon their food being such as excites and pleases their appetite. Nor should too strict a regard be paid, in many cases of sickness, to what is, however justly, considered "wholesome." Medicines are not exactly "wholesome," yet they are necessary for some persons; and foods not of very wholesome kinds are sometimes of use when the sick man's, or sick child's, appetite demands them. Care should be taken to distinguish between a genuine craving of nature, and a merely acquired taste, or a desire, such as that for slate pencil, which is a symptom of disease requiring a proper treatment. But with due prudence here, a very humble deference to the demands of appetite is the fitting mode of feeding the sick.

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* That the saliva may be well mixed with the food, is one reason for the importance of perfect mastication.

On this subject Sir Henry Holland remarks that "we are authorized to give greatest heed to the stomach when it suggests some seeming extravagance of diet. It may be that this is a mere depravation of the sense of taste; but frequently it expresses a real need of the stomach, either in aid of its own functions, or indirectly for the effecting of changes in the whole mass of blood. It is a good practical rule in such cases to withhold assent till we find, after a certain lapse of time, that the same desire continues or strongly recurs; in which case it may generally be taken as the index of the fitness of the thing desired for the actual state of the organs. In the early stage of recovery from long gastric fevers, I recollect many curious instances of such contrariety to all rule being acquiesced in, with manifest good to the patient. Dietetics must become a much more exact branch of knowledge, before we can be justified in opposing its maxims to the natural and repeated suggestions of the stomach, in the state either of health or disease.*

A surgeon of our acquaintance, in the case of a child apparently sinking from a lung disease, found out that anchovy paste pleased the palate, and, ordering it to be given freely, from that time appetite, and with it strength, returned. In another case, pickles were given with manifest advantage. It would be well if those who attend on any sick person should quietly notice any desires of this kind, and report them to the physician. Judgment is necessary, of course, and in health the ordinary rules of wholesomeness are less likely to be naturally departed from. So many articles of food also, such as pastry, are now made artificially nice with sugar and condiments, that the appetite becomes very liable to be led astray. In the fact, however, of the usefulness of pleasant tastes lies the explanation of the use of spices and other condiments, which are all good in their place; and the thought that it is not for pleasure only, but as a guide, and as a positive advantage in digestion, that the enjoyment of food is given us, might well make us doubly careful to preserve the sensibility unimpaired by pampering or excess.

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* The reader may find this subject philosophically treated in a volume by the late Joseph Catlow, of Manchester, entitled *Principles of Æsthetic Medicine.*

That in disease taste is often perverted, or for the time quite destroyed, is easily explained, at least in part, by the alteration of the fluids of the mouth and the thick layer of unhealthy secretion, or "fur," which covers the tongue, and cuts off the nerve from contact with the food. In fevers, and many other severe diseases, the tongue becomes also quite dry—another condition, as we have seen, incompatible with taste—and this may always be regarded as a serious symptom. But, on the other hand, the tongue should not be too "clean," especially after middle life; a certain amount of secretion on its surface is natural, and anything like a fleshy redness of appearance is an indication of disorder of digestion.

Taste is intimately connected with smell, as is well known to nurses: the common plan of holding the nose in administering physic being founded on a thoroughly scientific basis. In fact, as pointed out by Mr. Paget, not a few tastes may be strictly defined as odours perceived in expiration instead of inspiration. This may easily be tested by breathing out slowly through the mouth, immediately after swallowing a mouthful of tea.

Taste seems to be, indeed, not only in the manner in which it is most naturally indulged, but even in itself, an eminently *social* sense; and this may fairly go to raise it from the low rank in which, on some grounds, we cannot but place it. Not only are the most delicate flavours but half-enjoyable unless in refined and affectionate society, for—

> "What is a table richly spread,
> Without a woman at its head?"—

but the faculty of taste itself refuses to put forth its full powers except in association with other senses.

In this it is in pleasant contrast with some sensibilities of higher pretensions. When we are listening to music, for example, our eyes are no help to us: the dim religious light of the cathedral suits best the highest strains; even darkness might add sometimes to its sweetness and its power; all sensations but itself are intruders. But it is not so with taste. This genial faculty calls in both nose and eye to keep it company; for it is well known that in the dark the daintiest viands lose half their relish.

And there is no doubt a reason for this sociability, so to speak, of the sense of taste, in the fact that it is not dependent upon a single nerve, or a nerve discharging but a single function. Its two nerves, branches of some of the most widely-connected and highly-endowed nerve-trunks in the body, associate it intimately on the one hand with the remaining senses, and on the other with the chief internal organs. Thus the taste-nerve of the anterior part of the tongue is a branch of the nerve which supplies the whole face with its sensibility, including the eye, the nose, the teeth; and it is besides joined by a branch of another nerve which passes to it through the ear, and which certainly has a share in taste, besides helping to regulate the secretion of saliva. In this way the sense of taste, so far as it is seated in the front part of the tongue, is related to all the other senses, and to the great instrument of expression, the face; and accordingly we see how a strong acid (a taste which has its seat in the front of the tongue) throws all the muscles of the face into contortions, and will even bring tears into the eyes. But an acid taste, however strong, will never make us sick. This is a function of the nerve which gives the power of taste to the posterior part of the tongue: an entirely different one, which is connected very closely with those of the stomach, lungs, and heart. The tastes that make us sick produce their impression on this nerve, having through it an effect upon the throat and stomach precisely corresponding to that which an acid has upon the muscles of the face. Even a touch upon the parts supplied by this nerve, as by tickling the back of the throat, as is well known, will produce the sensation of nausea.

Perhaps it is not going too far to believe that it is for the sake of these wide-spread connections with other organs that the sense of taste—special and peculiar as it is—is not assigned to a special nerve, but is distributed between two nerves of general sensation. These wide relations are not matters of curious interest alone, but of most serious necessity. The very keystone and centre of our bodily life lies in this poor and menial faculty, that, uninstructed, teaches the whole world the things that are and are not good for food. The functions which taste discharges, therefore, demand its close and immediate intercourse with every part. In it, not so much one organ as the whole body acts; what the taste affirms or denies is the affirmation or denial of the whole frame. The sustenance and guardianship of the body are in the keeping of the tongue; but the tongue is bridled—nature has known how to tame it.

If it were not for these wide connections of the sense of taste, this wondrous gift of instinct would be even more mysterious than it is. Taken as the reaction of the whole frame upon the various substances that surround it, the power of choosing by taste the wholesome from the unwholesome, is just sufficiently intelligible to excite our highest interest. The body thus pronounces on the congenial and the uncongenial, concentrating itself into the point—finer than that of the finest needle—of a single nervous fibril; but being none the less the whole body acting there.

We cannot but compare—and with a boundless wonder—our own most delicate and varied choice with the simple and passive *affinities* and *attractions*, of which nothing is so low in nature as to be wholly destitute, and whereby all things seek one element and refuse another. And this universal power we trace upward from mineral to plant, which, without consciousness, but with an instinct as sure as, or surer than, our own, absorbs the nourishment and leaves the poison; and from plant to lowest animal, which—mere lump of jelly as it appears—folds itself closely round its fitting morsel and repudiates all else: wondering the while where consciousness begins and "attraction" is converted into taste; wondering, indeed, over more things than these, over many things, but chiefly this: what kind of *perspective* it is that rules our eyes as we look at nature, and makes things look so small as they recede from us, and how large they truly are.

If the sense of taste truly has a specially universal character, and more than the rest expresses the affinities of our whole bodily organization, then we can well understand why this faculty rather than any other has given its name to that finer sense to which art appeals, and which, when happily trained, enables men to recognise and delight in the truly beautiful alone. In taste, not only the body but the soul expresses its affinities, discerns and craves for the congenial, and seeks the sources of its development. Nor perhaps should the analogy ever be forgotten. A palate which the flavour of a poison does not repel has lost its guardianship of life; and so a man whom grossness does not shock, to whom refinement, purity, gentleness, heroism, have no charms, abandons his soul to death.

Before we leave the tongue, we must just glance at its movements. In this respect it is probably the most wonderful organ of the body; and, as might be supposed, a great many muscles co-operate to give it its various motions. A partial view of these is given in Fig. 6.

In the first place, the tongue itself is muscular, being chiefly composed of four distinct sets of fibres: of these, two sets run along its length, one above and one below; the third set pass, in a curved direction, from above downwards; and the fourth pass from side to side, also curved, like a shallow saucer. These last are attached to a dense partition in the centre, from which they radiate on either side. By these various muscles the tongue is expanded or contracted, and is bent upwards or downwards, or to the sides.

But, besides being thus itself a group of muscles, the tongue is moved by various other muscles which connect it with all the surrounding parts, some of which are shown in the cut. The chief of them is a large muscle which radiates like a fan from the inside of the chin to the under surface of the tongue, and serves to protrude it from the mouth (Fig. 6, *e*).

The motions of the tongue are also rendered more free by its being attached to a small bone situated in the throat, just above the projecting cartilage known as Adam's apple, and which bone is itself movable. But on this subject we may have more to say when we come to treat of the part the tongue plays in speech. It has a special nerve of motion, which is seen in Fig. 6, *k*, and which has numerous connections with the motor nerves of the surrounding parts, whereby they are brought into conjoint and harmonious action.

VI.

DIGESTION.

We are apt to forget that there are two meanings belonging to the phrase *inside the body*. A morsel of bread placed in the mouth is in one sense inside the body, but a needle run into the arm is inside the body in another and quite different sense. There is just the same difference here as between driving a coach and horses through the low and narrow gateway of the courtyard of an old-fashioned inn, and stepping from the uncovered yard into one of the many cosy chambers which surround it. The guest who stayed all night in the courtyard would gather but little hospitable comfort, and the food which we take would do us but little good, unless from being inside the body in one sense it came to be inside the body in the other sense. Digestion is, broadly, the passing of food from the general courtyard of the body into the many-chambered abode we call our flesh and blood. The doors that lead from the court are very narrow, so narrow that they can be hardly seen even when examined with powerful microscopes; and hence all the food we eat must be broken up, and divided into the smallest possible pieces, before it really gets within us.

In order to effect this, the whole of the alimentary canal is a busy scene of minute division. The moment any food passes into our mouth, it begins to be acted upon by forces which do their best to break it up into the finest possible particles, and the work begun there is carried on along the whole of the digestive track, until all the goodness that is in the food has been strained out of it. The forces are many, and of various kinds. Some are mechanical; by them the food is cut and ground, chopped and minced, rubbed and churned, until its smallest particles are worn down to the smallest size. Others are chemical; by them the solid food is reduced into the liquid state; that is, the molecules making up the solid particles are changed in form and nature, in order that they may pass almost anywhere. Digestion, strictly speaking, is a process of solution and of fine division.

These various forces, moreover, are brought to bear upon the food in succeeding districts; the food has to run the gauntlet of them all. What the mouth does not digest, the stomach attacks; and what the stomach leaves, becomes a prey to the intestine. We have thus digestion in the mouth, digestion in the stomach, and digestion in the intestine, each differing from the others, but all having this object in view—that the solid food should be converted into liquid material, capable of passing through the invisible pores of the membranous lining of the alimentary canal into the real flesh and blood, or be broken up into particles so small that they may squeeze themselves one by one through the minute openings which exist in certain parts of the intestinal wall.

The digestive process begins in the mouth; among civilized people it begins in the plate, or even before. Since the food will, if it be digested at all, be broken up, as we have said, into particles smaller than can be seen with the naked eye, the practice of cooking or softening and rendering friable the meat and vegetables of the meal, and of cutting them into small pieces before placing them in the mouth, may be considered as just an artificial and highly praiseworthy lightening of the labours of the frame. But it may lead to incidental errors. Undoubtedly mastication is the natural method of mincing meat, and not the least of its value lies in the fact that it takes time. A man who is eating a tough and therefore not very digestible chop will be slow in eating, if he is careful to masticate it well. There will be a long interval between each mouthful, and the stomach will run no risk of being hastily loaded.

Now, a hastily loaded stomach is as bad almost as, or rather is the same thing as, an overloaded stomach; and there can be no doubt that artificial mastication becomes a snare when it leads any one to introduce a large quantity of finely-minced meat suddenly and rapidly into an unprepared stomach, especially into the feeble stomach of an invalid, under the idea that, because the meat is so nicely minced and so very tender, it can be no possible burden to that sorely-tried organ.

Natural mastication has, besides, another advantage over the artificial process, which is perhaps not always recognised. Whenever food enters the mouth, it gives rise to what is called a flow of saliva. This saliva is secreted by certain glands, which pour into the mouth the fluid they strain off from the blood, and which are excited or stimulated to action by the presence of food in the mouth, as well as by other causes.

Now, putting aside for the present the action of this saliva on the food, either in the mouth or elsewhere, there can be no doubt, as we shall presently show, that it is itself a gentle and natural and yet most potent and useful stimulus to the stomach, urging that organ to pour forth a peculiar digestive secretion called *gastric juice.* Food itself is, of course, also a stimulus to the stomach, but it is at the best a rather rough and rude stimulus. The saliva, on the other hand, acts uniformly and softly; and most stomachs, like their owners, are more effectually led by gentle persuasion than by abrupt solicitation.

Moreover, the saliva is what is called an *alkaline* fluid. Throughout the whole of the animal economy there is constant play between acids and alkalies. By alkali, we mean such things as potash and soda, which turn red litmus paper blue, and whose properties are destroyed or suspended when they are mixed with acids. By acids we mean such things, whether ordinarily solid or liquid, as vinegar, vitriol, citric acid, etc., which turn blue litmus red, and whose properties are in turn destroyed, suspended, or neutralised, as the phrase is, by alkalies.

It is perfectly impossible to understand the chemistry of digestion, or the chemistry of any of the processes of the animal economy, without duly appreciating these characters of acids and alkalies. Upon them half the battle of life may be said to depend.

Well; the saliva is an alkaline fluid, and it is probably because it is alkaline that it serves so admirably as a stimulus to the stomach. The *rationale* of this we shall see by-and-by.

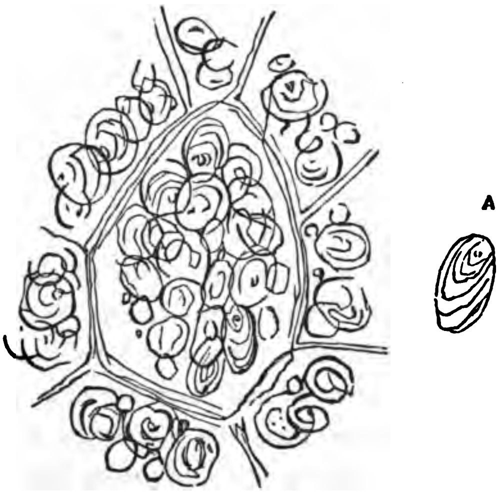
Meanwhile, we may remember this, that in mastication food is both finely minced and ground down, and also thoroughly mixed with saliva. By this means it is not only moistened, in order that it may easily and smoothly pass down the throat (and in this it is greatly assisted by the glairiness of the saliva), but also that, having descended, not too rapidly and in not too large mouthfuls, it may be in the best condition to call effectually upon the stomach to do its duty in bringing about the further changes that are necessary.

In many animals, especially in those which live on meat only, and probably even in many that live on grain, this is the whole of the digestive process that belongs to the mouth. In these creatures the food is simply masticated, softened, moistened with saliva, and rolled up into balls, preparatory to the act of deglutition. But, in ourselves at least, another very important chemical action is superadded to these mechanical ones.

A great part of our food consists of the material called starch. People who live sensibly because they are not rich enough to do otherwise, and people who, for other reasons, eat wisely, make starch, in one form or other, a very considerable element of their ordinary diet. When we call to mind that bread, potatoes, all farinaceous foods, and a great part even of green vegetables, consist very largely of starch, the truth of the statement we have just made becomes evident enough.

Now starch is stored up by the forces of vegetable life in the tissues of plants, not, for the most part, at least, as a formless powder, which can easily be ground finer, or perhaps still more easily dissolved, but in the shape of little grains of a very peculiar appearance when seen under the microscope, as is shown in Fig. 1.

FIG. 1.



SLICE OF RAW POTATO, MAGNIFIED 200 DIAMETERS.

Showing a vegetable cell, filled with a confused heap of starch corpuscles of all sizes. One of the starch corpuscles is seen free at A.

Various plants build up their starch granules or starch corpuscles in various ways, and an experienced microscopist, by examining a specimen of starch, can tell whether it came from potatoes or wheat or rice. But in every case the starch exists in the form of these corpuscles, which are little masses with a stout elastic exterior; and from what we said at the beginning of this paper, it will be at once evident that these corpuscles must be broken up before they can pass into the real inside of the body. Generally they are broken up during the process of cooking.

Under the action of boiling water, the envelopes of these corpuscles burst, and their contents become a sort of fluid. Every one knows that fresh unboiled starch, such as exists in arrowroot, stirred up with cold water, forms a milky fluid, from which, when it is left to rest, the starch settles down. The milkiness is due to the little starch corpuscles reflecting light. When the arrowroot is boiled, it becomes clear and transparent, because then the corpuscles burst, and their contents become a sort of fluid—a sort of fluid, but not a perfect fluid. That stickiness which is the great characteristic of boiled starch, and one of its most useful properties, is just an evidence that the material of the starch corpuscle has not been completely dissolved—has not been converted into a perfect fluid, capable like other fluids of passing through the walls of the alimentary canal into the blood.

Unboiled starch, therefore, would, if let alone in the alimentary canal, be of no use as food—the corpuscles could not pass into the body. Nor would simple boiled starch be much better, because of its not being a perfect fluid. The destruction of the corpuscles as corpuscles we bring about by the art of cooking, and they who neglect this preparatory digestion, and eat large quantities of uncooked starch in the form of half-cooked potatoes and raw vegetables, suffer for it by not digesting half of what they eat.

But boiled starch is converted almost instantaneously (and unboiled starch too, though much more slowly, and with much greater labour) into a perfect fluid by the action of the saliva. Any one can satisfy himself of this by taking a mouthful of the thickest possible arrowroot. After rolling it once or twice round the mouth, it will at once be felt that it has become perfectly thin and limpid. This cannot be due to the mere warmth of the body, as arrowroot is thickened, or "made" as is said, by means of heat. An absolute change has taken place in it—it is no longer starch, but sugar, and it is because it has become a mere solution of sugar that it is so thin and limpid. Saliva rapidly changes starch into sugar, and sugar is pre-eminently a soluble body, passing with the greatest ease from the alimentary canal into the blood.

There can be no doubt, that unless we eat with more than American rapidity, a great deal of the starch we consume is converted into sugar—is digested, in fact, before it leaves the mouth, and is therefore ready to be absorbed, as it is said—that is, to pass from the courtyard into the inner chambers of the inn without any further change.

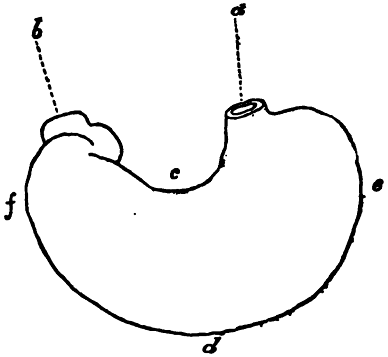
So far as we know, the food suffers no other treatment in the mouth than the kinds we have spoken of, and we will therefore next proceed to consider the changes which take place in the stomach.

Many persons do not exactly know where their stomach is, and a still larger number are apt to forget that it lies very close underneath the heart. So close to the heart is it, that it may, or rather very often does, when unduly distended with food or with gas, press upon or embarrass that important organ. This trouble is, of course, all the more likely to occur when the heart is enlarged; and if, as often is the case, that enlargement be accompanied by weakness, it becomes a matter of anxious care not to load the stomach with too much at one time.

The outline of the stomach is pictured in Fig. 2.

We may roughly indicate its position in the body by saying that while the broad end lies underneath the left-hand waistcoat pocket, the narrow end stretches into the middle line beneath the lower end of the breast-bone, in the region popularly called the pit of the stomach.

Fig. 2.



OUTLINE OF THE HUMAN STOMACH, ONE-FIFTH THE NATURAL SIZE.

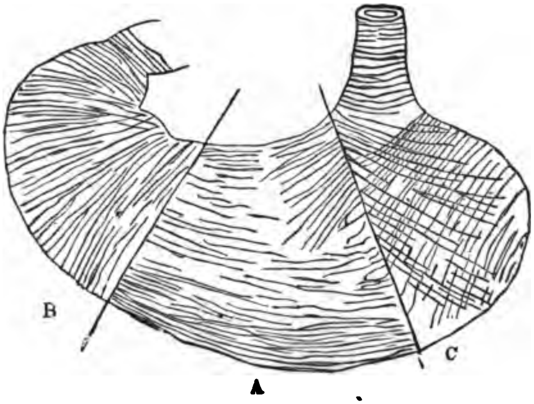
a. The entrance of the œsophagus. *b.* The pyloric orifice leading to the intestines. *c.* The lesser curvature. *d.* The greater curvature. *e.* The cardiac end. *f.* Intestinal end.

It will not escape notice that the food in passing down from the mouth by the œsophagus, or gullet, would fall upon the lower surface of the stomach. If left entirely to the force of its own gravity, the food would have a tendency to remain and gather together in a heap there instead of passing on to the further portions of the alimentary canal. In order to prevent this, and at the same time to produce other salutary effects, the stomach is gifted with a remarkable structure. Its general form is that of an elongated sac with two openings, but it is essentially a double sac—is made up of an outer sac lined by an inner sac. The outer sac is a muscular sac, and has a mechanical duty to perform; the inner sac is a glandular sac, and its office is a chemical one. Both sacs are joined loosely together; and there is yet a third sac—a sort of smooth coat covering the muscular one; but this is really an internal skin, and bears about the same relation to the muscular walls of the stomach as our skin, properly so called, does to the muscles of our limbs and body; and we need not pay much attention to it.

The muscular sac is represented with this skin taken off in Fig. 3. It is composed of a number of muscular fibres, not exactly identical with the muscular fibres which make up the mass of the flesh of our bodies either in structure or function, but still similar to them. These fibres are arranged in bands and layers, which pass over the stomach in various directions, as is shown in Fig. 3. Like all muscular fibres, they have the power of shortening or contracting from time to time; and they shorten or contract, not, like the muscles of the limbs, sharply and spasmodically, but slowly and deliberately.

Their action might be imitated by slowly squeezing a bladder or india-rubber ball half-filled with water, gradually tightening and relaxing the grasp while the hand is shifted from one part of the bladder to another. The effect of this would be to cause a movement of the contents of the bladder. By help of the particular arrangement of the fibres, this movement takes place in an orderly fashion, and the

FIG. 3.



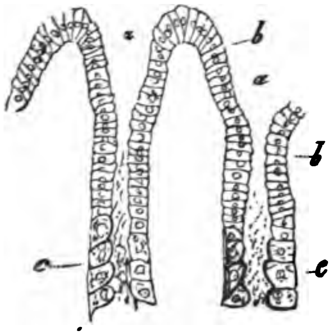
ARRANGEMENT OF THE MUSCULAR FIBRES OF THE STOMACH.

The regions marked A, B, C represent fibres as seen at different depths.

food courses regularly round and round the stomach. In fact, the mechanical sac churns the food within it.

While the food is thus being continually moved about, it is at the same time subjected to the action of the chemical sac. This is, as we have said, a glandular sac. It is of some thickness, and is made

Fig. 4.



UPPER PORTIONS OF THREE GASTRIC GLANDS, MAGNIFIED.

a. The mouth of the gland. *b*. The inert cells lining the mouth. *c*. The active peptic cells.

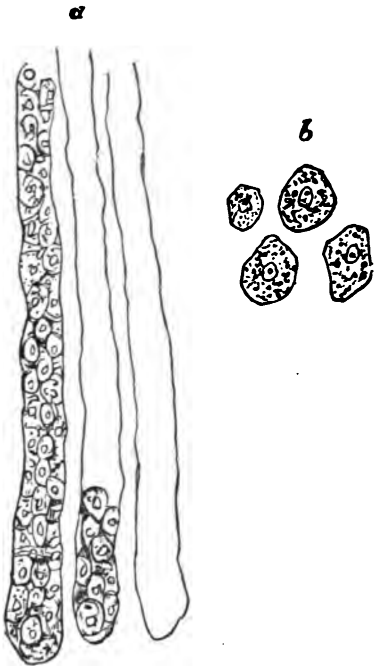
of little glands bound up together with that stringy fibrous packing material which is found in all parts of the body, and which anatomists call *connective tissue.*

If we were to imagine many gross of small india-rubber phials all placed side by side, and bound together with hay or straw into a great mat, and the mat rolled up into a sac, with all the mouths of the phials turned inwards, we should have a large and coarse, but tolerably fair image of the glandular coat of the stomach. Each phial would then represent one of the glands of this coat, one of the *gastric* or *peptic* glands, as they are called. Each gland, however, is not always a simple tube, but is often branched at the bottom end, and all of them are lined, except just at their mouths, with large rounded bodies, which not unfrequently almost choke up their cavity.

Fig. 4 represents the mouths of three of these gastric glands; Fig. 5, the other ends of three others; and Fig. 6, a branched gland. The rounded masses, or cells as they are called, in the interior of each gland, form the really active part of the apparatus. Each cell is a little laboratory, which concocts out of the material brought to it or near it by the blood a certain potent, biting fluid, and is hence called a peptic or digestive cell. Each cell is born at the bottom of the tube, and in process of time travels upwards towards the mouth. When it reaches the mouth, it bursts, and pours into the stomach the fluid it has elaborated, or perhaps may give it out without bursting, while it is still within its tube.

In those cases in which it has been possible to look in upon the stomach while at work (as in the famous case of the Canadian who received a wound in the side, penetrating the stomach, which never thoroughly

Fig. 5.

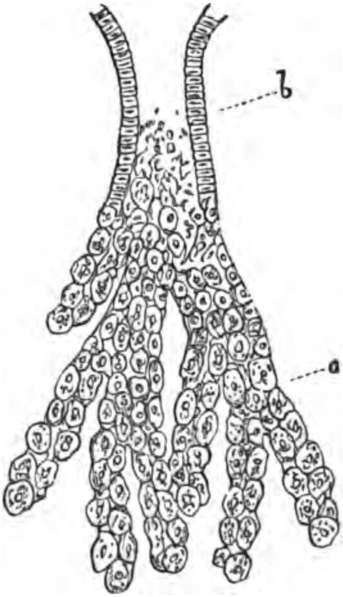


LOWER PORTIONS OF THREE GASTRIC GLANDS, MAGNIFIED.

One is filled with peptic cells; another is nearly empty; the third is simply a membranous tube, which has lost all its cells. At *b* are seen several of the peptic cells more highly magnified.

healed, and thus left a hole from the outside into that organ), and where the orifices of the tiny glands (for, though we have compared them to bottles, they are exceedingly small) appear like little dots, tears were seen to start at the mouths of the glands, gather into drops, and finally trickle down into the lowest part of the stomach. The stomach, as it were, weeps; and indeed the weeping of tears is just such another effect of glandular activity—only ordinary tears form a mild

Fig. 6.



BRANCHED GASTRIC GLAND.

a. The peptic cells. *b.* The inert cells.

and, chemically speaking, impotent fluid; while the fluid which the tears of the stomach form—the *gastric juice*, as it is called—is a sharp piercing water of excessive chemical power. It is by the solvent action of this gastric juice, very materially assisted by the churning action of the muscular coat, that the food suffers those changes which make up what is called gastric digestion.

We have spoken of the gastric juice (which, when obtained in a pure state, is a clear or nearly clear watery-looking fluid, often, however, mixed with thick viscid mucus) as a sharp fluid. It is not only sharp and somewhat bitter to the taste, but also most distinctly acid, and in this point differs most decidedly from saliva. Its action, too, is very different from that of saliva. We have seen that saliva dissolves starch; gastric juice not only has no action on starch, but actually prevents saliva from so acting, so that the change of starch into sugar, which began in the mouth, is arrested as soon as the food reaches the stomach.

But gastric juice has an intense effect on other elements of food, against which saliva is powerless. Every joint of meat is made up of fat, bone, gristle, and the material which forms the great mass of the meat or flesh properly so called. Now this meaty material is met with, under the names of nitrogenous or albuminoid or proteid substances, not only in meat and eggs and other articles of animal food, but also in almost all vegetable foods. The gluten of wheat is such a substance. Potatoes, rice, and greens, all contain some of it. The curd of milk is a proteid body, so is the basis of cheese, some of it even clings to butter. In fact, in nearly every article of food, certainly in every meal, it is a prime factor.

Now, in its natural state, either in the solid form of meat and muscular fibre, or in the more liquid glairy form of unboiled white of egg (in which latter it exists naturally in almost its purest form), proteid matter has a great objection to being soluble, a very great repugnance to passing through the walls of the alimentary canal into the real interior of the body. In order to make it pass, it has to be thoroughly dissolved, and this thorough solution is very easily effected by gastric juice. Even out of the body it will readily reduce first into a pulpy mass, and then into a limpid fluid, pieces of meat or boiled egg, especially when the mixture is warmed up to the temperature of the body, and frequently shaken. And inside the body the change is effected with much greater rapidity.

It may be urged that unboiled white of egg is itself a fluid, but its ropiness is a distinct evidence of its want of perfect fluidity, and, as every one knows, it becomes a perfect solid when boiled. Very different from ordinary white of egg is the fluid which is produced when either boiled or unboiled white of egg has been for some time digested. This fluid does not become solid, does not coagulate, as is said, even when boiled ever so long. Moreover, if unboiled white of egg is put into a bladder, and the bladder, after being tightly tied up, sunk in water, little or none of the albuminous part of the white of egg will pass through the walls of the bladder into the water. But digested white of egg similarly treated will pass with the greatest ease. So much more fluid, so much more movable and slippery in its atoms and molecules, is the digested proteid.

This is briefly the whole duty of gastric juice, the sole work of the glandular coat of the stomach. By it starch and fat are very little if at all affected, but it pounces on all proteids, and, assisted by the churning action of its muscular coating, bites and gnaws away at them as they are careering round the stomach. Under its action, the fragments broken by the teeth are softened, and break up into still smaller pieces. The small pieces melt away into a perfect fluid, and thus become capable of passing through the fine invisible pores both of the delicate membranes which form the framework of the glandular tubes, and of the equally delicate walls of the blood-vessels, which wrap round those tubes like a network of fine threads round an india-rubber bottle. In this way the digested matters are drawn off into the blood, and become part and parcel of the fluid stuffs of the body proper.

The bones and gristle are broken up and dissolved in some such way as the proteids; but the starch and fat, and such fragments of meat, skin, and other matters, as escape the action of the juice, are ready to be passed on, by the grasping, pushing squeeze of the muscular coat, to the other districts of the digestive tract, where further ordeals and other changes await them.

Such is the process of digestion in the stomach; but, unfortunately, it is often accompanied by another process called indigestion. The causes and kinds of indigestion are legion, but they may be thrown into two classes.

In the first place, the secreting glands may be seriously damaged and permanently impaired. Under rough treatment, they get worn out. They wither up; their rounded cells shrink and waste; their mouths get blocked up with adventitious material, or tightened and closed with bands of misplaced tissue. In these cases there is little help, save by artificial digestion and by careful economy of the waning powers of the organ; and their occurrence is a warning against the cruel and careless treatment of such tender structures.

When it is remembered that the tears which flow into the eyes when dust or any foreign matter gets into them, are but an image of the tears of a sensitive stomach, which weeps gastric juice whenever it is touched, it will be readily understood what havoc is played when neat brandy, hot peppers, and a host of stinging, biting, and cutting condiments are recklessly poured into its exquisitely sensitive cavity.

All these things act, and are used because they act, as so many goads or stimuli to the gastric glands, and for that reason the wisdom of using them lies entirely in the measure in which they are used. No organ in the body will work unless it is called upon to work; but no organ will stand being exercised beyond the limit of work which is natural to it. A horse may go all the better for a little whip, but the best horse in the world would soon break down under continued and laboured thrashing. Unhappily, we flog our stomachs even more than we do our horses, not because we want them to go, but because we find we can't get them to go; and, for the sake of temporary success, sow the seeds of future permanent failure.

The other and more common forms of dyspepsia are of a more temporary nature, and, at the present day, come about, for the most part, in an indirect way.

These gastric glands, for instance, like all other parts of the frame, require themselves to be nourished; and when the body wastes, either from complete or partial starvation, or from some enemy, in the shape of disease, robbing the tissues of all the goodness of the food that is brought to them by the stomach, they, in common with all other parts and organs, grow weak. They flag in their work, the juice they prepare is thin and powerless, and, the more they want nourishment, the less are they able to digest and accumulate nutritious material for themselves or for the body at large. Hence, to a starving seamstress, or to a patient recovering from fever—much as they need food—food is a burden, and must be doled out to them little by little and in the most digestible form.

The glands, also, like other parts of the body, are subject to the influence of the nervous system; and, by means of that system, are placed *en rapport* and sympathise with other parts of the body. A subtle influence, carried along certain nerves, may paralyse these glands, stop their work, and dry up the stomach, just as similar influences dry up the mouth through stoppage of the flow of saliva. Every one knows how fear, anxiety, or pain, so check all saliva, that the tongue cleaves to the roof of the mouth; in such cases, starch may be held in the mouth without undergoing any change into sugar. No digestion in the mouth goes on. And just the same takes place in the stomach. A man goes to dinner with his mind full of fears, anxieties, and troubling thoughts. His stomach is dry—his gastric glands are stopped in their work, as by fright—and the meal lies a heavy, unchanged, undigested lump, in a powerless cavity.

Or, on the other hand, something indigestible—something unsuitable—is eaten, and the glands resent the insult. They strike work. They are made and constructed to digest certain things; and, if they are solicited to undertake duties not in their business, they refuse.

In all these cases of temporary indigestion, the means of remedy are threefold.

The first is, especially in cases of indigestion from want of power, or from ill-directed and ill-timed nervous action, to give the stomach as light and as digestible food as possible. The more frequently it is given, the sooner will the frame, if it receives the nourishment kindly, recover its power; but it must not be given too frequently, for these glands require times of rest like every other part of the body.

Secondly, one may administer to the body food already digested—artificially digested. This is a means of treatment which as yet has hardly received any great practical extension; but it seems to promise a great deal. It is very easy to digest artificially a large quantity of meat; and by this means a quantity of palatable fluid capable of passing at once as digested nourishment into the blood without troubling the gastric glands at all, might be prepared. Probably in a few years this will be largely done.

Lastly, we may create a sort of artificial gastric juice. We said that gastric juice was a biting, sharp liquid. It owes its power, partly to its being acid, and partly to its containing a peculiar active matter called *pepsin*, which is really a sort of ferment. Acids alone will not dissolve meat, or dissolve it very very slowly. Pepsin, by itself, does not act on meat at all; but pepsin and acid together will, sooner or later, dissolve up all the proteids that are presented to them.

Hence, if we give a flagging stomach both acid and pepsin, we give it the means of carrying on digestion without having recourse to its own capital of strength. Under the idea that there is always enough acid in the stomach, pepsin (or a mixture of various things, containing actual pepsin among others, and sold under the name of pepsin) is frequently given as a medicine. And under the idea (which is much nearer the truth) that in ordinary stomachs the great want is not pepsin, but proper acid, this latter is frequently given alone, with great benefit.

But in giving these things, we must remember how sensitive and touchy the stomach is. Very frequently when we offer a stomach additional acid it is offended, and ceases to secrete even the small quantity it was pouring out before. On the other hand, by the common physiological law that things act as stimuli because they are unlike, strange, and foreign to the bodies to which they are presented, the presence of an alkali spurs the stomach on to pour out more acid, and hence, even for the production of acid, a little gentle alkali is the best stomachic; and perhaps the best stimulus of all is the alkaline saliva. But the due and careful administration of these artificial aids to digestion belongs rather to the medical art than to popular physiology.

VII.

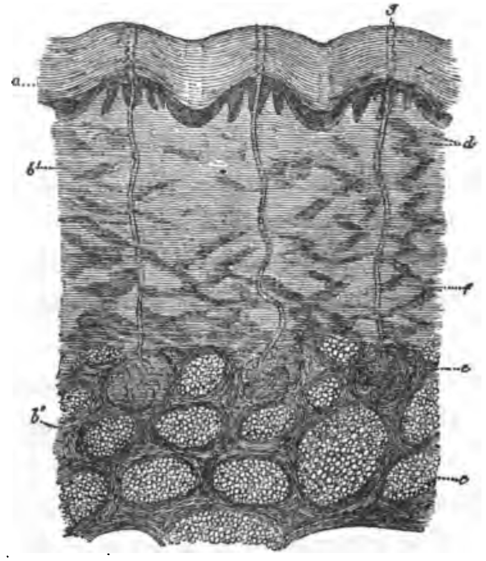
THE SKIN.—CORPULENCE.

The skin is a complex structure, which forms a covering to the outer surface of the body, and protects the deeper and more vital parts. It is the chief seat of the sense of touch, and has also other most important offices to discharge. At the various orifices, the nostrils, mouth, etc., it is continuous with the membrane which lines the internal parts, the *mucous membrane* as it is called. At these places there is no sudden change from skin to mucous membrane, but a gradual transition from the one to the other. And the structure of the mucous membrane is very similar to that of the skin, being modified chiefly by the fact that it is not constantly exposed to the air. Hence, when for some reason or other a portion of the mucous membrane comes to the surface, its features are altered, and it gradually assumes the character of skin; and if a portion of skin occupies an internal position, it in turn becomes converted into mucous membrane. The physician has many opportunities of observing the close connection which subsists between these two structures. Thus it often happens that a derangement of the mucous membrane gives rise to a disease of the skin, or that when an affection of one of them subsides, disease is lighted up in the other. It is well known, too, that medicines which act specially upon the one generally act upon the other also. Thus, there is no medicine which is so frequently used, nor so frequently abused, as arsenic in the treatment of skin diseases,—a remedy which often requires to be stopped owing to its action upon the mucous membrane of the lungs.

The skin is composed of two layers, the scarf skin or cuticle (*epidermis*), which forms a covering and protection to the deeper-seated and sensitive parts; and the sensitive skin or true skin (*cutis vera*), which contains blood-vessels and nerves and little glands, and which differs very materially from the other, not only in its structure, but also in its functions. The deepest layers of the sensitive skin consist of a loose network of what is termed *connective tissue*, that is, very minute fibres which are gathered into bundles and cross one another in all directions, leaving little spaces, which, however, are not empty, but filled more or less completely with masses of fat. (Fig. 1, *c*.)

It is this accumulation of fat which imparts that ness and smoothness to the skin which constitutes one of the greatest beauties of youth; and it is to its diminution that the furrows and wrinkles of age are in great measure to be attributed. For this reason it is that these are almost absent in persons who, although advanced in years, are more or less corpulent.

FIG. 1.



PERPENDICULAR SECTION THROUGH THE SKIN OF THE BALL OF THE THUMB.

a. Scarf skin. *b′*, *b″*. The two layers of the sensitive skin. *c.* Masses of fat. *d.* Papillæ of skin. *e.* Sweat glands. *f.* Their ducts. *g.* Opening of the ducts upon the surface.

The deepest layer of the skin is of great importance, too, in so far as it forms a soft elastic cushion, the yielding of which allows a certain degree of movement to the upper layers, and prevents or diminishes the liability of these parts to be injured by pressure or violence.

Were it not for this provision, it would probably be impossible for the soles of the feet to bear for any length of time the whole weight of the body, for the horseman long to maintain his seat upon the saddle, or for the mechanic to bear the pressure of his tools upon the palm of his hand.

The quantity of fat accumulated in the subcutaneous cellular tissue, as it is called, varies extremely in different parts of the body, as well as in different persons. Thus it is usually abundant over the stomach, and scanty on the head, back of the hands, top of the feet, etc.

The excessive accumulation of fat beneath the skin constitutes what is termed *corpulence* or *obesity*. But it must not be supposed that in such cases the deposit is limited to this situation; for it is found also in great abundance in internal parts; and although in the former situation it strikes the eye, and seems to the uninitiated the most important element of the disease, for disease it must be called, in the latter it [illegible] rise to much more inconvenience; nay, even in some cases to very serious results, for it not only renders the subject of it painfully large and unwieldy, and diminishes very materially the power, and therefore the inclination, for exertion, but it also presses upon, and interferes with the functions of, the inward parts; thus, its undue accumulation in what is popularly called the *stomach* (but technically the *abdomen*), by pressure upwards, prevents the free action of the heart and lungs, and leads, among other evils, to shortness of breath; while its deposit about the heart itself still further interrupts its functions, and may even paralyse it altogether.

While, no doubt, the tendency to obesity is inherent in some constitutions, and in part is hereditary, a great deal of it is generally to be attributed to the habits of the individual; for let a man who is predisposed to fatness, sleep much, walk little, drink freely, especially fermented liquors, such as ale, porter, and cider, and eat like a glutton, especially indulging in large quantities of fatty articles of diet, or of sweet things which in the system are converted into fat, or of food containing much starch, such as potatoes, which is converted into sugar and then into fat, and obesity is the natural result.

Hence there is a good deal of truth, but not the whole truth, in the remark that the cure of fatness consists in keeping the eyes open, the mouth shut, and the legs in motion. For, of the innumerable instances in which persons have attempted to reduce themselves by early hours, active exercise, and a diet approaching to starvation, failure has been the almost inevitable result. The secret of success lies in the abstinence from fatty articles of diet, and from food rich in starch or sugar. This has long been known, though too little recognised by the medical profession. But, it should be remembered, the sudden adoption of such a regimen is not without danger; many lamentable instances of which have of late years come under the notice of medical men. For, while it is wonderful how the system accommodates itself to altered circumstances, the change must be gradual, or the revulsion will lead to disease. It is partly on this principle that the removal of the leg of a person who has been recently injured in the midst of health, is much more likely to lead to fatal results than when the operation is performed in consequence of old standing disease.

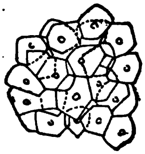
But we must leave the subcutaneous cellular tissue, which is the deepest layer of the sensitive skin, and inquire for a moment into the nature of its superficial layer, or *corium*, as it is called. The latter, like the former, is principally composed of connective tissue, with this difference, that the fibres are much more closely interwoven, so that there are no intervals filled with fat, and accordingly it is a much denser and less yielding structure than the subcutaneous cellular tissue. Its upper surface is not smooth, but marked by innumerable minute prominences, the "papillæ" of the skin, which are very important structures. It is freely supplied with blood-vessels and nerves, hence the pain and bleeding which result when it is pricked; and each of the papillæ is furnished with a minute blood-vessel or nerve, or both. Those upon the inner surface of the hands and fingers, and also upon the feet, are arranged in double rows, and accordingly, on examining these parts, since the scarf skin takes on the impression of the papillæ, innumerable little curved lines are seen separated from each other by minute depressions. It is in the papillæ, and especially in those to which nervous filaments are distributed, that the sense of touch mainly resides.

In most situations, and especially where there are hairs, the sensitive skin is furnished with very minute muscles (or *sinews* as they are popularly called), which are attached to the roots of the hairs, or of the oil glands, to which we shall refer shortly. The contraction of these muscles has the effect of rendering the hairs more prominent, of making them "stand on end" under the influence of fright, and it is also the cause of that roughness of the skin which is observed under the influence of cold and the like, and which is termed *goose-skin.*

All persons are familiar with the blisters, as they are improperly called, which are raised by the sting of the nettle; and too many are acquainted with a similar eruption which resembles the sting of the nettle, and which is therefore termed *nettle-rash.* Now it has been found very difficult to explain this peculiar appearance, owing to the suddenness with which it comes and the rapidity with which it goes; but it appears to the writer that if we attribute it to a spasmodic contraction of the muscles of the skin, not only may the appearance which it presents, but also the suddenness of its rise and fall, be satisfactorily accounted for.

We have seen that the sensitive skin is composed almost exclusively of fibres, and contains innumerable little blood-vessels and nerves; whereas the scarf skin, which forms a covering to the former, contains neither fibres, blood-vessels, nor nerves, but is almost entirely made up of an endless number of little plates or scales (*epithelial scales*), which are soldered together so as to form a uniform structure. (Fig. 2.) The plates composing the upper layer are quite flattened, very closely packed, and to a certain extent, especially in some situations, almost horny in consistence, so as to give protection to the deeper-seated sensitive parts; while the cells composing the lower layer are arranged more loosely, and instead of lying flat have a vertical direction. The under surface of the scarf skin is not smooth, but marked by little depressions, into which the papillæ of the sensitive skin fit as the fingers into a glove.

FIG. 2.



SCALES OF WHICH THE SCARF SKIN IS COMPOSED.

The division of the skin into two layers is justified, not only from the marked differences which they present structurally, but also from the fact that, although closely united, they are not inseparable. Most of our readers must have seen, either on their own persons or on those of their friends, the effects of a common blister. The skin is said to rise, and a quantity of fluid, derived from the blood, accumulates beneath. But it is not the skin, only the scarf skin, which is thus raised out of its bed, and separated from the parts beneath. And accordingly, when the blister is cut [that is, the scarf skin removed] and the fluid escapes, the patient complains of pain, which is the natural result of the exposure to the air of the upper layer of the sensitive skin.

The scarf skin, like the rest of the body, is continually undergoing change and decomposition. New plates or scales are being constantly formed at the point where the scarf skin and sensitive skin meet, while the old scales are in like measure thrown off from the surface. In a state of health this takes place so slowly, so regularly, and so methodically, that it is not perceived; but it is far otherwise if inflammation attacks the skin. Although the scarf skin contains neither blood-vessels nor nerves, it is endowed with life, and when inflammation attacks it the scales die in great numbers, and are thrown off from the surface to such an extent that they attract attention; and this excessive fall of scales is termed *desquamation.* This is well illustrated by the peeling off of the skin which follows all attacks of scarlet fever in which the eruption has been distinct. Most persons, too, are familiar with what is popularly termed *scurf of the head,* and which follows even slight inflammation of the scalp, resulting from impairment of the general health, or the like.

The use of soaps is governed more by scientific principles than is generally believed; for all soaps contain an alkali (usually soda), while the scarf skin is chiefly composed of albumen, a substance which is readily acted upon by alkalies. The soap thus softens, dissolves, and removes the superficial layers of the scarf skin, and with them the dirt which has accumulated.

Much ignorance prevails amongst the public as to the use of soap and water. It is possible to carry everything to excess, and physicians occasionally witness a superficial irritation of the hands and face, as the result of the too frequent use of soap and water, or of water alone. Those who have very sensitive skins should use soft water, for the face at all events; and the best water, if it can be had, is rain water with the cold taken off it. Nor is it every kind of soap which is tolerated by such persons. Thus, what is called *black soap* is one of the most irritating of all; while probably the safest soaps are, not those which are said to contain, but those which really do contain, a large proportion of glycerine.

In an interesting article, entitled "Longevity and Centenarianism," in the *Quarterly Review,* the following remarks occur: "Records and experience concur in furnishing cases of great tenacity of life under the most directly opposite conditions. Men have lived beyond a hundred years without walking more than a hundred yards a day, from house to office and back. No! it depends not on exercise, nor yet, if we dare breathe it in an age wholly given to 'tubbing,' on frequent ablutions or strict cleanliness. Witness 'Lady Lewson,' to whose peculiar views on this topic a cutting short of her days cannot be objected. Witness Elizabeth Durieux, a woman of Savoy, whom a writer in *Notes and Queries* saw when she was 119 years old, bony, large-limbed, wrinkled, and *very dirty*." Witness, as a nation, the Icelanders, of whom a Quarterly Reviewer says that "though very uncleanly, and suffering much from skin diseases, and leprosy particularly, their average longevity exceeds that of the continental nations of Europe."

Are we, then, to infer from the preceding remarks, that cleanliness is injurious to health? It is almost unnecessary to answer in the negative, for the cases alluded to are undoubtedly exceptional; the longevity, owing to peculiarities of constitution, climate, and the like, being attained in spite of dirtiness of habits. The irritation of the skin, too, which sometimes follows the use of soap and water, is due, not to regular and systematic, but to constant and excessive, ablution.

It must never be forgotten that the body is constantly changing, the old tissues being replaced by new ones, and one of the most important functions of the skin is to assist in the removal of the effete matter from the system. If, however, strict cleanliness is not observed, the pores of the skin, through which this is accomplished, become choked up, and the evil result in the long run to the general health cannot be doubted.

The account of the scarf skin would be imperfect were we to omit allusion to those innumerable little coloured particles (pigment granules) which lie embedded in the cells of its deepest layer, and to which the variations in the tint of different skins is due. Most of our readers have probably at some time or other seen an albino; that is, a person with colourless skin, white hair, and red eyes. Now this peculiar and striking appearance is entirely dependent upon the fact that the skin and other structures are devoid of the usual pigment granules. This condition is observed at birth and continues throughout life, but no satisfactory explanation can be given of the reason for its occurrence. Again, the dark colour of the brunette, as compared with the blonde, is due to the darker colour of the pigment in the former, as compared with the latter; while the colour of the negro is owing to the pigment granules being nearly black. Some persons are born with brown patches on different parts of the body—moles, as they are called; while others exhibit a peculiar distribution of the pigment of the skin, that is to say, it is altogether absent at some parts, while at others it is excessive, so that patches of colourless skin are surrounded by others of a dark colour, and if the head is implicated in the disease, the hair proceeding from the colourless parts is white. This deformity, which is termed *vitiligo,* is sufficiently striking amongst the white races; but in the negro the appearance, as may be imagined, is exceedingly remarkable, and he is commonly called a *pied-negro.*

The late Dr. Addison was the first to direct attention to a peculiar discolouration of the skin occurring in connection with disease of an internal organ,* and called *Addison's disease* in honour of its discoverer. This discolouration is dependent upon the deposit in the skin of an excessive quantity of pigment, and may implicate only portions of the skin, or the whole of it, in which case the patient resembles a mulatto, or a bronze statue the gloss of which has been removed. The occurrence of this discolouration in connection with an internal malady is worth noting, as being a good illustration of that sympathy which, through the influence of the nervous system, exists between organs remote from one another.

Light and heat, and especially the latter, have a powerful influence upon the deposit of pigment;

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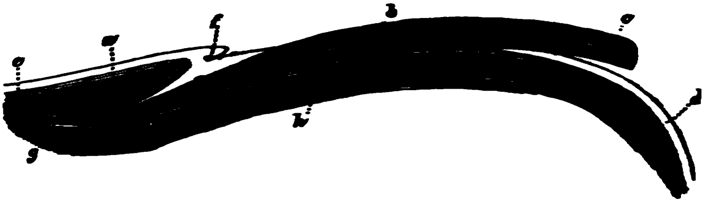
* Of certain little bodies attached to the kidneys, and called the "supra-renal capsules."

indeed, it is favoured by anything which tends to increase the amount of blood in the skin; hence the brown colour of the exposed parts in some persons during the summer months, and the freckles which disfigure the face so much in others. And most persons must have observed the brown mark which is sometimes left after powerful stimulation of the skin, as for example after the application of a mustard poultice or a blister, and which is dependent upon the same cause.

The nails are mere modifications of the scarf skin, their horny appearance and feeling being due to the fact that the scales or plates of which they are composed are much harder and more closely packed. The root of the nail lies embedded, to the extent of about the twelfth part of an inch, in a fold of the sensitive skin, and as may be observed from an inspection of the part, the scarf skin is not exactly continuous with the nail, but projects a little above it, forming a narrow margin. (Fig. 3.)

The nail, like the scarf skin, rests upon, and is intimately connected with, a structure almost identical with the sensitive skin; this is, however, thrown into ridges, which run parallel to one another, except at the back part, where they radiate from the centre of the root. (Fig. 4.) On examining the surface of the nail, a semicircular whitish portion is detected near its root, which is dependent upon the fact that the ridges there contain fewer blood-vessels, and therefore less blood,

FIG. 3.



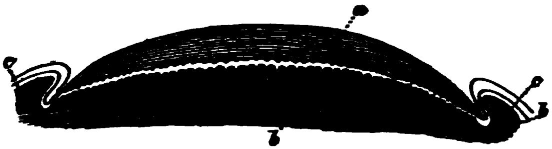
SECTION THROUGH THE NAIL AND ITS BED, ALONG THE FINGER.

a. Root of nail. *b.* Body of nail. *c.* Free end of nail. *d.* Skin of tip of finger. *e.* Skin of back of finger. *f.* Scarf skin on upper surface of nail at its root. *g*, *h.* Bed of nail.

and on account of its half-moon shape it is called the *lunula.*

The nail is constantly increasing in length owing

FIG. 4.



SECTION OF THE NAIL AND ITS BED, ACROSS.

a. Nail. *b.* Its bed. *c.* The skin overlapping the nail at the sides.

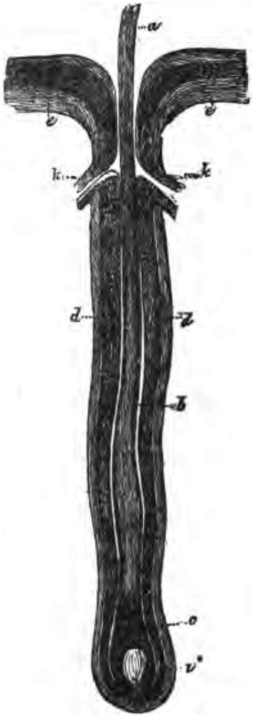
to the formation of new cells at the root, which push it forwards, while the increase in its thickness is due to the secretion of new cells from the sensitive layer beneath, so that the farther the nail grows from the root, the thicker it becomes. Its nutrition, and consequently its growth, suffers in disease, the portion growing during disease being thinner than that growing in health; and accordingly a transverse groove is seen upon the nail, corresponding to the time of an illness. It will thus be seen that by a mere examination of the nail we can astonish our friends by telling them when they have been ill; and it has been estimated that the nail of the thumb grows from its root to its free extremity in five months, that of the great toe in twenty months, so that a transverse groove in the middle of the former indicates an illness about two and a half months before, and in the middle of the latter, about ten months.

The culture of the nails, which when perfect constitute so great a beauty, although their neglect is not so deleterious as in the case of the skin, is of much importance; but the tendency is to injure them by too much attention. The scissors should never be used except to pare the free edges when they have become ragged or too long, and the folds of scarf skin which overlap the roots should not, as a rule, be touched, unless they be frayed, when the torn edges may be snipped off, so as to prevent their being torn further, which may cause much pain, and even inflammation. The upper surfaces of the nails should on no account be touched with the knife, as is so often done, the nail brush being amply sufficient to keep them clean, without impairing their smooth and polished surfaces.

In the feet, the nails or their beds are often the seats of disease, much of which is due to the use of ill-fitting and especially tight shoes—as, for example, in the case of the so-called "ingrowing toe-nails," while ulceration beneath the nail is a very common and exceedingly painful affection, for the cure of which it is often necessary to remove it altogether; for the nail presses upon and irritates the sore beneath, and prevents it from healing. In some cases, too, a low form of vegetable life takes root, grows between the nail and its root, and injures it very much, or even causes it to fall off. There are many others diseases of these parts, to which, however, our space will not permit us to refer.

On all parts of the body provided with hair, the skin is the seat of innumerable minute depressions (hair-sacs), from which the hair grows. (Fig. 5.) At the bottom of each sac is a little elevation, termed the *papilla*, which is almost identical in structure with the papillæ of the skin, to which we have already referred. It is from the papilla that the hair draws its nourishment, and from which the new hair grows when the old one has fallen out or been extracted. There is a very common belief, which is shared by many medical men, that if the hair is extracted it will never

FIG. 5.



HAIR AND HAIR-SAC.

a. Hair shaft. *b*. Root of the hair. *c*. Bulb of the hair. *d*. Hair-sac. *i*. Papilla of hair. *e*. Reflection inwards of the skin at the aperture of the hair-sacs. *k*. Ducts of the sebaceous glands.

grow again. Were such the case, it would certainly be a great boon to those who are troubled with superfluous hair. But, unfortunately for them, not only does the hair reappear after extraction, but it tends to grow stronger than before, and, within certain limits, the oftener the operation is repeated, the greater is its strength and luxuriance. The reason of this is obvious. The extraction of the hair irritates the papilla, and causes a rush of blood to it, so that extra nutriment is provided for the growth of the succeeding hair.

An examination of the hair with the microscope reveals to us the fact that it is chiefly composed of fibres, closely packed together, and that each is enveloped in a thin skin or cuticle, composed of square-shaped cells, while many of the hairs—the white and coarse ones in particular—are marked by a central streak, called the *medulla*, corresponding to the pith in the stems of plants, and which is also composed of cells. Scattered here and there over the hair, a number of dark streaks and spots are usually to be seen, composed partly of air-cells, but principally of pigment, such as we find in the skin itself; and it is to the varying quantity and tint of this pigment that the differences in colour of the hair in different persons, and on different parts of the body, are mainly to be attributed. We know that the hair has a tendency to vary in colour at different periods of life; that it is darker, as a rule, in the adult than in the infant, and that its silver-grey colour is one of the ornaments of age, although some persons are foolish enough, from a desire to appear younger than they really are, to disfigure themselves by the use of wigs, which are both unseemly and unsuitable. The source of these changes is to be found in the increasing quantity and deepening colour of the pigment granules as adult life is approached, and in its diminution and ultimate disappearance in old age. Most of our readers have probably heard of cases in which, under the influence of violent emotion, such as sudden fear or intense grief, the hair has turned grey in a single night, but much scepticism exists as to the possibility of such an occurrence. While, however, such cases are certainly rare, it is an undoubted fact that they do occur, and that they are not the mere offsprings of a lively imagination. And a very curious circumstance has been discovered with regard to them, namely, that the change of colour is not dependent upon the disappearance of the pigment of the hair, which can only take place slowly, but upon the sudden development in its interior of a number of air-bubbles, that hide and destroy the effect of the pigment, which remains unaltered. One or two such cases may be mentioned.

Ludwig Harenburg had long been intemperate in his habits, in consequence of which he was seized with delirium tremens. The delirium, as is usual in such cases, was of a very terrifying nature, and it was specially noticed that the entrance into his room of any one who was unknown to him agitated him, and made him tremble from head to foot for two or three minutes. The delirium had lasted four days. On the evening of the fourth day the hair was unaltered, but on the morning of the fifth the delirium had disappeared, and his hair, which previously was fair, had become grey. It was examined with the microscope, when it was found that the pigment was still present, but that the central streak of each was filled with air-bubbles. (Virchow's *Archiv*, 1866, p. 589.)

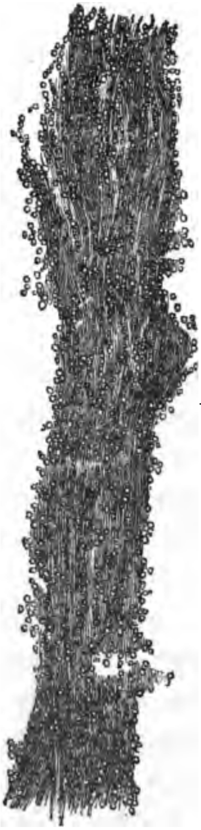
A young Swiss, armed with a sabre, suspended himself over a precipice by means of a rope, in order to secure some young vultures in their nest. While in the act of taking them, he was attacked by the mother, and used his sabre freely to protect himself. When the encounter was over, on looking up he found that he had nearly severed the rope which supported him. He almost died of fear, for a yawning precipice was beneath him. Fortunately the rope was strong enough to support him, but by the time he reached the summit his hair had turned grey.

One other case, which is related in a work by a celebrated physician, Daniel Turner, now no more, may be added. Don Diego Osorius, a Spaniard, of a noble family, being in love with a young lady of the Court, had prevailed with her for a private conference, under the shady boughs of a tree, within the garden of the King of Spain; but by the unfortunate barking of a little dog, their privacy was betrayed, the young gentleman seized by some of the king's guard, and imprisoned; it was a capital offence to be found in that place, and therefore he was condemned to die. He was so terrified at the hearing of his sentence, that one and the same night saw the same person young and old, his hair having been turned grey as in those stricken in years. The gaoler, moved at the sight, related the incident to King Ferdinand, as a prodigy, who thereupon pardoned him, saying he had been sufficiently punished for his fault.

In a state of health, the hair, when it has grown to a certain length, falls out; but this shedding of the hair is such a slow process, that it produces no deformity, and almost passes unobserved. It is far different, however, when the health is reduced, as after a fever, for then it falls away in such abundance as to produce well-marked thinning of the hair, and to cause much uneasiness. Such a condition is not to be neglected, partly because of the deformity which results, but mainly because it indicates that the general health is in an unsatisfactory state. Again, many persons must have seen cases in which the hair has a tendency to fall away in certain parts, leaving round bald patches; and instances are known to the writer, of the successive implication of different portions of the hair, until not a single hair was left upon any part of the body. It is supposed by some that this disease is dependent upon a minute plant which eats away the hair; but the most recent investigations tend to show that it is not so, but that there is some peculiar alteration of the nerves of the affected portions of the skin. There are certain diseases of the hair, however, which are undoubtedly due to the implantation and germination of minute fungi, of which we have a good illustration in the disease too well known under the name of ringworm of the head; and it is this circumstance which imparts to it its contagious quality. (Fig. 6.) This minute growth not only eats into the portion of hair which is above the surface, and causes it to break, but also finds its way into the root; and hence the difficulty of reaching it with remedial agents, and the obstinacy of the complaint in certain cases.

The skin is provided with innumerable little glands, the *sweat glands* (or perspiratory glands), and the *oil* *glands* (sebaceous glands), as they are called. The former (Fig. 1, *e, f*) are little tubes, the walls of which

FIG. 6.



HAIR FROM A CASE OF RINGWORM OF THE HEAD LOADED WITH AND BROKEN UP BY THE SPORES OF A FUNGOUS GROWTH.

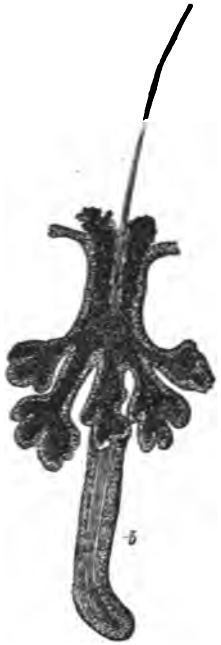
are similar in structure to the layers of which the skin is composed. The orifices of these glands, the pores of the skin, are oblique, because the little tubes in their passage through the scarf skin have a spiral form; in the sensitive skin they lose this spiral form in great measure, but terminate in little coils of tubing in its deepest layers. The whole length of each tube has been estimated at a quarter of an inch, and the whole number of tubes in an adult at more than two millions; so that, if it were possible to place them end to end, they would reach to the extent of nearly ten miles.

The perspiration is composed almost exclusively of water, of which more than two pounds are discharged in the day. This fact is sufficiently striking to warn persons of the danger of allowing the pores of the skin to be closed from want of cleanliness.

In health, in a state of quiescence, the skin is comparatively dry, for the moisture passes off in the shape of vapour as soon as it is discharged; hence the term *insensible perspiration* has been applied to it. But when the circulation is unusually excited, under the influence of exertion or of heat, or when the patient is extremely weak, as in consumption, the little glands secrete profusely, and the skin is moist; and to this the term *sensible perspiration* has been given. The secretion of these glands, like that of the other organs and tissues of the body, is under the influence of the nervous system; hence, in cases of violent emotion, such as sudden fear, we break into a profuse perspiration. Hence the sympathy which exists between the skin and the other excreting organs, there being a balance of function between them; so that, when the skin is secreting freely, the internal excretions are diminished, and *vice versâ.*

It must not, however, be supposed that the skin is an organ of excretion only, for it is endowed with a considerable amount of power of absorption. It is on this account that a certain degree of relief from thirst has been experienced by shipwrecked mariners from the immersion of their clothing in salt water; and that when physicians desire to keep the stomach at rest for a number of consecutive hours, they sometimes envelop the limbs in wet bandages. Many persons, too, are familiar with the application to the skin of a belladonna plaster for the relief of pain; yet it is not generally know that the absorption of medicines by the skin has been carried to such an extent as to produce serious symptoms of poisoning. The scarf skin, however, very materially interferes with the process of absorption, and accordingly, when a speedy effect is desired, a portion of the cuticle is frequently removed by means of a blister, and medicines applied to the raw surface of the sensitive skin, which absorbs them with great rapidity, so that much care is required in this mode of administering drugs.

FIG. 7.



SEBACEOUS GLANDS FROM THE NOSE SURROUNDING (*b*) A HAIR-SAC.

The oil glands are distributed over the greater portion of the skin, but they are far more abundant in hairy parts. The ducts of these glands are similar in structure to the tubes of the sweat glands, but they are broader, and most of them open into the hair-sacs instead of communicating directly with the surface. The little glands themselves vary very much in character, many of them being simple dilatations of the extremities of the ducts, while others are divided into several little sacs, as in the accompanying illustration (Fig. 7). These glands secrete an oily substance, thus ridding the system of certain noxious elements, while at the same time the surface of the skin is protected from the air, and the injurious effects which might otherwise be expected to arise from the rubbing against one another of neighbouring folds of skin are prevented.

An examination of the secretion squeezed out of the oil glands has proved that they often contain a minute parasite, which is supposed to serve some useful purpose, such as the stimulation of the glands, or the consumption of a portion of their secretion. At all events, they are found in persons whose health is perfect, and do not give rise to the slightest inconvenience; but it is by no means certain, as some have asserted, that they are to be found in the glands of all persons.

It not unfrequently happens that the secretion hardens, accumulates in and distends the ducts, especially in the faces of young persons; and as the secretion at the orifice of each attracts the particles of dust which are floating about, a number of black specks are to be detected, which must be familiar to all our readers. And if a watch-key be pressed firmly against the skin, being so placed that the hollow of the key corresponds to one of the black specks, the secretion is tilted up and appears in the shape of a worm-like process, being an accurate mould of the duct from which it has been expressed. The prolonged retention of hardened sebaceous matter in the glands is very apt to irritate and inflame the surrounding parts, and to give rise to the disease called *acne*.

Instead of the ducts of the glands, the glands themselves may become distended with their secretion, and then, there being no contact of the secretion with the air, there are no black specks; but the appearance presented is that of little pearly points, owing to the sebaceous matter shining through the distended skin. This is a condition often met with in the eyelids and face, and is termed *milium* by scientific men.

Lastly, the secretion from the glands may be excessive —may diffuse itself in undue quantity over the skin, and is very apt, especially on the head, to dry up into yellowish scales, such as we often see in infants, and to be mistaken for inflammation. For all these con- ı, it is well to seek medical advice.

VIII.

THE BATH.—THE SENSE OF TOUCH.

IN the last chapter we gave a short account of the structure and general use of the skin, but there remain one or two points, more or less connected with this portion of our frame, which deserve a few further remarks. Of these, we may take first the use and abuse of bathing.

Bathing has two objects: to purify and to strengthen. These are intimately connected, since nothing tends more to enervate than contamination of the fluids which circulate within the body, and to remove superfluous or worn-out substances is a direct way to impart vigour to all the organs; but it is not in this way alone that bathing strengthens. By virtue of the change of temperature a cold bath implies, it acts, as is well known, upon the nervous system, and calls out, in answer to the temporary abstraction of heat, a freer play of the general vital powers.

Of the bath as designed for ordinary purposes of cleanliness, there need not much be said. The whole surface of the body should be daily washed; but the daily use of soap need not be considered necessary, except for those portions of the body which are specially exposed. For the general surface the use of soap twice a week fulfills the demands of cleanliness, unless in special occupations. Warm water, as is well known, cleanses much more effectually than cold.

The Turkish bath, lately re-introduced with high commendations into this country, has its chief use as a means of thorough cleansing. Not, indeed, that by it, as some of its too enthusiastic advocates have implied, every kind of morbid agent can be washed out of the blood. Diseases cannot be filtered away through the sweat-glands. Still, by the profuse perspiration which the high temperature induces, aided by the drinking of a few tumblers of water, a great deal of highly objectionable matter may be got rid of. Persons with weak hearts should be careful how they have recourse to the Turkish bath, although in some cases otherwise adapted, and under careful medical supervision, persons suffering from confirmed heart-disease have derived the greatest benefit from its use. But for all other persons an occasional recourse to it is a legitimate luxury, and for some a decided advantage. The temperature of the heated air, however, should not exceed 150°, except under medical advice, or after careful trial. If exhilaration and a feeling of increased lightness and proneness to exertion follow, benefit has been gained; if lassitude and exhaustion, the bath is unsuitable, or its duration or temperature should be diminished.

The free perspiration induced by the Turkish bath, judiciously taken, is in most cases beneficial; but it should not be supposed that there is any special virtue in this particular means of inducing it. Active exercise is a better one for all persons who can take it; and a walk or a game, which within the bounds of moderate fatigue produces a copious secretion from the skin, and on which no chill is allowed to supervene, does fully as much to eliminate ill materials from the blood, as the most sedulous votary of the Turkish bath can attain. The latter, indeed, regarded as a means of health, may be looked upon most justly as a kind of substitute for bodily exertion, when this is unattainable through lack of strength or time—a substitute, that is, in this one respect, but by no means in all, for exercise does much more for us than merely carry off fluid through the skin.

The Turkish bath accordingly is most suitable for those who, from unavoidable causes, are compelled to lead sedentary lives, especially if they suffer from want of sufficient activity of the secreting organs. To them it affords a partial supplement for more natural and effective sources of invigoration. It is useful also for those to whom the free use of cold water without previous warmth is too severe a shock, the high temperature drawing the blood freely to the surface of the body, and so preparing it to receive with advantage the cold affusion with which the bath concludes. For the principle on which cold succeeds warmth in the Turkish bath—and it is one which all bathers should bear in mind, as it determines whether the practice is beneficial or the reverse—is this, that the circulation in the skin should be vigorous, and the temperature accordingly warm, so that its temporary depression from the cold may be followed by a vigorous reaction. This is, indeed, the criterion of the influence of a cold bath; whether it leaves behind it a pleasant glow upon the surface, or a feeling of chilliness: *if the former, it invigorates; if the latter, it enfeebles.* In this respect a great deal depends upon the time that is passed in the water. There are few persons who are not warmed by a single plunge; still fewer who are not chilled, and therefore injured, by a prolonged stay. On an average, three minutes should suffice, except for those who are inured to the practice, and unless the weather is very warm. For active swimming in the sea, ten minutes may be taken.

The glow which follows a cold bath, is the chief secret of its tonic influence. It arises from the blood returning in a larger stream to the surface, from which it had been partially banished; and it has these two good effects: it is a safeguard against chills, through the increased supply of blood to the external parts, and for the same reason it wards off internal congestions and other disturbances of the circulation. And besides this effect upon the blood-vessels, it adds another to those natural stimulants of the sensitive nerves, on which, as we have before observed, the healthy tone of the nervous system so much depends. All these good effects are much aided by vigorous friction with a flesh-brush or rough towel, applied as rapidly as may be. It is bad to let the surface continue wet after leaving the water.

The best time for prolonged bathing is the forenoon, say two or three hours after breakfast; but for a simple plunge no time is better than immediately on rising. The skin is warm on quitting the bed, and in a good state to receive the shock. The cold bath should not follow immediately on a meal, because the blood should not then be drawn too strongly to the surface, it being required for the work of digestion.

The question has been a good deal discussed, whether a cold bath should immediately follow a walk or other exercise; and an opinion to the contrary has widely prevailed, backed by certain stories, which, however, are probably incomplete in some of their details. Accordingly it is much the custom after exercise to wait until the body becomes cool, before bathing; and in some schools it is made the business of a master to see that no boy enters the water in a state of perspiration. This opinion and practice, however, appear to be ill-founded. If evil effects have resulted from bathing after exertion, it has been not because the body was hot, but because its powers were exhausted by fatigue. Under such circumstances the danger of a cold bath is not diminished, but increased, by waiting until the heightened temperature has passed away. The power of reaction, from the weakness of which the danger arises, is thereby only rendered still more feeble. The proper rule is, that cold bathing should never be had recourse to after great fatigue, whether we be heated or not, but, under all circumstances, it is better to encounter it warm than cold; and there is no better preparation for it than a moderate walk, sufficient to induce a slightly heightened temperature. Thus employed, a daily cold bath is a safe tonic for almost all persons during the summer months, and tends especially to restore the appetite when it has been lost.

Some persons of heroic mould persist in a cold plunge throughout the year, and regularly break the ice whenever the frost is severe. Of this practice we can only say that it seems to be good for those who are strong enough to bear it, but such persons undoubtedly are few. The luxury is attended with risks, and should never be persisted in if a feeling of warmth does not immediately succeed it.

The shower bath has some advantages over the plunge; the stimulus to the nerves of the skin is greater, the abstraction of heat somewhat less. It is useful, therefore, to certain nervous temperaments; but some precautions are advisable if there is any lack of strength. It is a good plan, for instance, to stand in a pan of warm water to prevent the feet from being chilled, or in some cases to protect the head by an oil-skin cap. It is indeed often desirable not to apply cold water too freely to the head; and many persons who derive great advantage from cold bathing find it advisable to use tepid water for the head. This seems to be especially the case with those who are subject to great mental labour, and who sometimes increase the nervous distress to which they are subject by an unwise use of cold water for its relief. But bathing the face with cold water is often a great refreshment during mental strain, and nothing calms the sleeplessness which results from excitement better than its free application to the face and neck.

It does not appear that washing the head with tepid instead of cold water, or the use of tepid baths, increases, as might perhaps have been thought likely, the liability to colds. As a rule, it may be said that water which, although tepid, is decidedly below the natural heat of the skin, so as to give a feeling of coldness, has a bracing—that which feels warm, a relaxing—effect. The use first of warm and then of cold water has an excellent influence, and is admirably adapted for those who are for the time too weak to bear cold alone; but they should succeed each other immediately, and the room should be warm.

In bathing infants it is desirable to cover them all over with a shawl or flannel, and to wash them beneath it. With this precaution they may be washed without a fire in the coldest weather. And here appears a palpable defect in the bathing arrangements of most people. Till about four years old, children have a daily bath, then as a rule they go without it till the age of sixteen or so, when the wiser ones resume it again if they can. But what is desirable is, that the practice of daily bathing should be continued all through life; which it doubtless would be if the necessary conveniences existed. In every house there should be a bath supplied with hot and cold water available for every member.

Warm baths should not be taken, except under medical direction, oftener than about once a week. Vapour baths, also, are rather a remedy for disease than a means of health. There are many contrivances for giving them, of which the simplest is a hot brick placed in a bucket of water beneath a chair. It should be remembered, however, that such plans are not free from a risk of scalding.

Passing now to the endowments of the skin as an organ of sensation, we cannot but notice their great variety. The skin is the seat of many senses rather than of one. The perception of heat and cold, for instance, is as different from the feeling of a solid body, as seeing is from tasting. Tickling, again, is a quite peculiar sensation; so also is the sensibility to pain, which resides in the healthy state chiefly on the surface. The reason for this heaping up of sensitive capacities in the skin, of course, is obvious in the fact that it is the medium through which we come directly into contact with external nature. All our other senses may be for a time unexercised; but, save in sleep, the skin gives us incessant information. It takes part in all our actions, and furnishes guidance in the attainment of every end. Little as we reflect upon it, it is unquestionably true that, so far as knowledge is concerned, we had better lack every other organ of sensation than the skin. If we had not clear apprehensions from our touch, our eyes would present to us mere illusions, words would have no solid meaning on which higher senses could be built up. It is that recognition of separate substance which the fingers give, that first reveals to the dawning consciousness of the child his own individuality; on the basis of that recognition of substance the eye traverses space, and translates a faint glimmer of light into a world; on that same basis the bewildering variety of appearances in Nature stand before the mental eye as an endless series of motions, fulfilling in every change a perfect order.

There is scarcely any sense that the skin cannot in some measure supplement. Blind men by its aid have learnt to distinguish colours; by its aid the deaf listen and the dumb converse. Nay, as the case of Laura Bridgman proves, let a man be born into a dark and silent universe, eyeless and earless, cut off from every charm by which Nature endears herself to us, from every means by which humanity acquires and stores up its growing knowledge; yet can the sense of touch, by loving nurture, still give him a happy place among his fellows.

The touch is indeed remarkable for the improvement it may receive from practice. The blind soon come to read with perfect ease a raised type not much larger than that of an ordinary large-print Bible. Saunderson, a professor of mathematics at Cambridge, blind from two years old, could distinguish genuine medals from counterfeits better than many good judges who possessed their sight. Many blind persons have become good sculptors; others have been famous botanists; and Dr. Carpenter mentions a blind friend who has so thorough a knowledge of shells that he takes rank with the best conchologists. Perhaps this great development of touch-power is not merely due, as in the case of the ear or eye, to practice; for the touch differs from these latter organs in this respect, that while the nerves of hearing and of sight are provided with an apparatus for specially receiving and concentrating light and sound, the nerves of touch are invested with a covering specially adapted to *deaden* their perceptions; namely, the outer layer of the skin. The sense of touch, therefore, may be susceptible of being rendered more acute by an alteration in this layer of *scarf-skin* itself, which may give the nerve a less impeded access to its object.

In some aspects the touch is the fundamental sense, of which all the others are but modifications and developments; the motions of light and sound strike upon the ear and eye, so that seeing and hearing are but touching at a distance. Perhaps indeed there is not truly the difference there seems to be; for no two bodies, so far as can be discovered, ever come into absolute contact, so that in our firmest grasp we really touch at a distance, and feel not substance, but only force. But however this may be, this simplest of the senses certainly yields to none of them in wonder.

The seat of the sense of touch is in the minute papillæ of the skin, before described. These, accordingly, are most numerous in those parts of the surface in which the sensibility is most acute, as on the tips of the fingers, the lips, the point of the tongue. On the palmar surface of the hand they are arranged in rows, and so give rise to the lines which mark this part of the surface. From 12,000 to 30,000 are here contained in a square inch. By means of a pair of compasses, it is easy to test the sensibility to touch of different parts of the body. The eyes being closed, the two points of the compasses are applied so as to touch the skin at a short distance from each other, and it is found that the power of distinguishing them as two separate points varies very greatly with the situation. On the tip of the tongue they are felt as two at the distance of half a line; on the point of the third finger, at the distance of one line; while on the back and the middle of the arm no clear sensation of two points of contact is given until they are two inches and a half apart. These, at least, are the average distances, but they vary a good deal in different persons.

If a part, such as the finger, possessed of a delicate tactile perception, touches another part which is less sensitive, such as the arm, it is the finger which feels the arm, not the arm the finger, unless the temperature of the two parts is different, for then both are felt. The sensations of touch also are persistent after the removal of their causes, like those of the other senses, but in still greater degree. Thus an earring may be felt long after it has been removed; and in a similar way an irritation of the skin will frequently persist when the cause has ceased to operate.

In appreciating *weight*, it has been found that the small hairs which cover the surface greatly assist, since the delicacy of the perception is much diminished when these are shaved off. This fact favours the view that the peculiar hairs with which some animals, such as the cat, are endowed, are tactile organs.

The perception of heat and cold has a fair claim to be regarded as a special sense; and some facts observed in disease seem to indicate that there are special nerves devoted to it. It is certain that the sensation requires for its production a special nervous structure in the skin, for experiments have shown that it cannot be excited when the skin is destroyed. Neither is it perceived in any of the internal organs. A sense of cold or heat is felt from hot or cold substances swallowed only when the skin is affected by the change of temperature in the parts within. Beyond a certain point, heat and cold alike produce a sensation merely of pain. Frozen mercury and red-hot iron feel alike. The larger the surface involved, the more intense is the feeling of temperature. Water at 104 degrees seems less warm to one finger than water two degrees lower seems to the whole hand. The left hand seems to have usually the acutest sense of temperature.

There is another class of sensations, those which constitute what is termed the *muscular sense*, or feeling of exertion, which are also closely connected with the sense of touch. This muscular sense it is that gives us the consciousness of the amount of effort we put forth in any action, and thus conveys to us the feelings of resistance and solidity; and, like touch, to the perfection of which it is essential, it resides chiefly in the hand, though it is present in every part. It is, indeed, the union of this sense, in its utmost perfection, with nearly the most perfect sense of touch, that makes the hand the wonderful instrument it is. We may judge of the part the muscular sense plays in touch, by getting a friend to move one of our fingers over a smooth surface, while we shut our eyes. If he presses more firmly at one part than at another, we receive the impression of an *unevenness* in the surface; which we do not have if we exert a varying pressure ourselves.

But besides being thus concentrated in the hand, the muscular sense comes into play, consciously or unconsciously, in every voluntary movement. By its teaching we adjust the strength we put forth to the demands of every action, and are able with a little experience to exert just so much as will suffice to attain the end. Through it we are able without thought to maintain the constant series of muscular actions by which the body is maintained in an upright position, and which could not cease for a moment without a fall. But the most wonderful instances of the operation of the muscular sense are seen in the muscles which adjust the ear and regulate the voice, so that persons with a good ear can reproduce with the utmost accuracy the boundless variety of tones, for each one of which a different kind or degree of muscular contraction is required.

How entirely dependent our actions are on the *muscular sense* which guides them, is proved by some cases of disease, in which, though the muscular power remains, sensation is destroyed. In these cases there is an entire inability to act, unless the wanting muscular sense is supplied by the sight. Thus "a patient who cannot feel either the contact of his foot with the ground or the muscular effort he is making, can manage to stand and walk by *looking* at his limbs; and a woman who cannot feel the pressure of her child upon her arms can yet sustain it so long as she keeps her eyes fixed upon it, but no longer; the limb dropping powerless the moment that the eyes are withdrawn from it." But it is not only in disease that our actions are essentially aided by our sight. In our ordinary movements we "lean," as Professor Mayo said, "upon our eyesight as upon crutches;" and there is scarcely one in which the closure of the eyes does not introduce embarrassment, until by practice the muscular sense is trained to supply their place.

Nor is it only in acting that the muscular sense and the eyesight co-operate. It is by the union of these two senses that distinct apprehensions of the world around us are obtained; and *perceiving* may be said to be the bringing to bear upon the object the conjoint powers of sight and touch. If without touch the eye would give us but appearances; without the aid of knowledge gathered by sight, the touch would impart to us little definite information, and would be subject to many illusions; for though this sense seems to bring us more directly than the rest into relation with the very substance of things, it also has its liabilities to error. For instance, if the second and third fingers be crossed and a small object be placed between them, the feeling given is that of two distinct objects: this feeling, no doubt, arises from the relations of the nerves to each other being altered.

In various diseases, again, illusions of the sense of touch are present, showing that in this mode of perceiving nature, as in others, there mingles also something from ourselves. Our feeling of solidity, for example, answers to our own exertion, and may be produced not only by solid substances, but by various kinds of force, as on trying to bring together the corresponding poles (which repel each other) of two powerful magnets. We must not think that by any one of our senses we can penetrate the secret of the universe. Light itself is but a shining veil; no eye has seen what nature is, nor hand has felt it in its grasp. Perhaps it is not without significance that, in the sense of touch, which seems to bring us closest to the world around, there is interposed a special impediment to cut us off from a contact too direct. It seems an image of our state—a parable engraved on each man's hand, to remind him that in all that he perceives there still is something hidden; something that it would need a finer sense, a higher faculty than ours, to apprehend aright. Nor can we wonder that it should be so. What else does our experience of nature suggest, but some mighty Power, betraying itself by wondrous flashes, but never wholly revealed? We have examined —most briefly and imperfectly indeed—in previous papers the various organs of the senses, and have seen what science tells us. We have discovered structures most beautifully adapted for receiving mechanical and chemical impressions, and conveying them to a central organ of nerve-cells and fibres. But how does this explain our sensations? What light does it cast upon the thrill of joy we feel in beauty, the rapture with which music carries us away? These questions suggest one answer, and but one: that there is more in that which causes our sensations than we are conscious of. As the scarf-skin clothes and dulls the nerves, which could not bear, for pain, an unimpeded touch, so there is a darkness clothes our souls, and dims for us a glory too bright to bear. And therefore we see now but as through a glass, darkly, not only the Creator, but His works; and therefore in us nature's harmony is broken.

There is one other thought: the hand and eye—not each in its own sphere alone, but used together—give us true knowledge of material things. Even so, if man is to read Nature rightly, and gain but a faint glimpse of her true meaning, the heart and intellect, united, must furnish him the key.

IX.

NOTES ON PAIN.

It can scarcely be a pleasant occupation to read about pain; yet there are few who have not felt it, and feeling it, have wished to know something of its nature, its cause, its object, or its treatment. Any one of these questions would give ample scope for a chapter, but we have designedly headed this "Notes on Pain," since it is our purpose to allude only to some of its more prominent characteristics.

Pain may be due to many sources, but its most frequent causes seem to be an excess of blood or an intensity of nerve-currents, for the violent excitation of any sensation is painful, although the moderate excitement is pleasurable. We may, however, remark, that in the nervous apparatus of the organs of special sense—the eye, the ear, etc.—congestion, or intense excitement of nerve-currents, does not cause pain, but in the eye flashes of light, in the ear unusual noises, in the tongue peculiar tastes, evidence a deviation from the normal state.

The tendency of protracted intellectual work to expend force, exhaust physical power, and so induce premature decay, is well known. Long-continued concentration of mind is exhausting, though it may seem easy and pleasant. Even pleasure itself implies an expenditure of blood and nerve-tissue, to the stinting, perhaps, of the active energies and intellectual processes. But pain is a more costly experience than pleasure; being accompanied by excess of blood in the brain arising from intensity of nervous action and conflicting currents (both of which are sources of waste), it uses up vital force more rapidly and wastefully than muscular or intellectual work. The feeling of ennui or sense of failure, from unsuccessful effort, is akin to pain, and is very wearying and depressing. Mere excitement may detain thought and impress memory, but does not waste power as pain does.

The mention of excitement induces us to notice in passing that the disappearance of pain under strong mental emotion is no proof that the pain itself has been a creation of the fancy; for a powerful emotion may so modify the course of the circulation, as to withdraw the attention from the seat of pain, and so relieve local congestion.* The influence of pain in enfeebling the action of the heart is very great; and when the blood is poor and the circulation weak, the supply of force obtained from the food, and available for muscular or mental work, is soon exhausted, and a sense of tiredness, passing into pain, occurs. Pain, too, may actually arrest secretion; and, by allowing the accumulation of effete matters in the blood, may poison the nervous system, disturb the serenity, and confuse the mind.

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* The following incident well illustrates the extent to which pain may be dependent on fancy: "A butcher was brought into a druggist's from

We have so far regarded pain as a cause of the expenditure of vital force, but pain is also a consequence of the faulty removal of waste products. The pain of gout, rheumatism, ague, etc., is due to the presence in the blood of a material which acts as an irritant to the sentient nerves, and often continues for a long time after the removal of the poison. The long continuance of pain may keep up a turgid state of the vessels of the brain and render sleep impos-

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the market-place opposite, labouring under a terrible accident. The man, on trying to hook up a heavy piece of meat above his head, slipped, and the sharp hook penetrated his arm so that he himself was suspended. On being examined, he was pale, almost pulseless, and expressed himself as suffering acute agony. The arm could not be moved without causing excessive pain, and in cutting off the sleeve he frequently cried out; yet when the arm was exposed, it was found quite uninjured, the hook having traversed only the sleeve of the coat!" The sensation here was perfectly real, but originated in a change in the brain and nerves, instead of in the external senses.

sible. The nutrition or restoration of nerve-tissue, which ought to go on during sleep, is suspended, waste products accumulate, and interfere with clearness of intellect and happy activity of mind. Miserable restlessness and irritability are in this way engendered, which themselves may give rise to hypochondriasis, melancholia, or brain disease.

We may notice the influence of pain on the lower animals, on different races of the human family, and on different individuals. Shakspeare says—

> "The poor beetle that we tread upon,
> In corporal sufferance feels a pang as great
> As when a giant dies."

Modern discovery entitles us to offer an opinion on the truth of this poetic axiom. Pain, "nature's kind harbinger of mischief," being given for wise purposes, acute perceptions could scarcely, in accordance with our enlarged views of the beneficence displayed in the construction of the universe, be supposed to exist in animals who have no power of avoiding dangers; and, inasmuch as, in the higher animals at least, the power of feeling pain exists in the brain, it is natural to infer that where this organ is wanting, the sensibility to pain would be absent too; and that, as this part of the nervous system becomes more perfect, the power of feeling pain would increase. In other words, as the strength, activity, and intelligence of an animal, by which it can escape from pain, depend on the perfection of the brain, so does the perception of torture depend on the condition of the same organ. Apart from science and theory, every-day observations show us that, among many of the lower animals, the feeling of pain is not acutely developed. The fly seized by the leg will leave its limb behind, and with apparent unconcern wing itself away to regale on the nearest sweets; and of so little moment is the loss of a limb to a lobster, that he will throw off his claws if alarmed by the report of a cannon. Talking, barking, and grunting animals scream more when hurt than those that use but little language, as the horse, sheep, or cow.

Not only does a difference exist in the sensibility to pain evinced by man, as compared with the lower animals, but between the various races of the human species the diversity is almost as marked. The power of bearing pain without exhibition of feeling, as cultivated by the stoical Spartan, varies greatly in different persons, and in the same person at different times; and it cannot be doubted that, irrespective of relative fortitude, there is a real diversity in the nervous susceptibilities of different persons and races of mankind. To some it is natural to be loudly demonstrative, and they, perhaps without less real fortitude, cry out vociferously where another man, or a man of another nation, would not flinch. We may, on the other hand, often learn a lesson in resignation from the calm behaviour of those whose delicate organization must increase their susceptibility to pain, and who yet bear without a murmur agony the most continuous and excruciating. It is said of the late Sir Robert Peel, that his sensibility to pain was excessive; and no one would accuse him of a want of fortitude. In the same person the sensibility to pain varies: at one time the application of a blister is as "nothing;" at another it is "agony." Not only does the organization of the sufferer affect his capacity for endurance, but the very nature of the pain itself has a considerable influence on the question: for some pains are more readily borne with equanimity than others, and this apparently quite independently of the intensity of the suffering. In gout, for instance, proneness to irritability, both mental and physical, is an almost inseparable symptom of the disease; and great indeed must be that man's fortitude and power of endurance who can bear without exhibition of temper the height of the gouty paroxysm, and remain calm and uncomplaining throughout the attack. The unbearable severity of gouty pain is such as to render every thought but of the pain impossible. A well-known barrister, who is a martyr to neuralgia, while he has been perfectly unable to concentrate his mind on his case when labouring under an attack of gout, has often conducted a cause when suffering from a paroxysm of tic-douloureux. Although pain may be well-nigh intolerable, it is not therefore always an index of serious mischief; and though so acute in gout and rheumatism, it is often altogether absent in far more fatal maladies. In consumption, for instance, it is not uncommon for the sufferer to be free from pain, even to the last. And in some rare instances the occurrence of pain may even be a proof of a change for the better.

We have seen that, as was to be expected from the variation in their respective organisms, a distinction may be drawn between the susceptibility to pain of the lower animals and of man; that a difference in this particular likewise exists between two men of the same race—indeed, in the same man at different times, or under different circumstances. We may carry the distinction one step farther, and notice that in the various parts of the same body there is a different susceptibility to pain, a difference due to the structure of the organs, and the distribution of the sentient nerves.

In tense unyielding tissues, as those which cover the bones and cartilages, the pain from swelling caused by inflammation is intense, while in lax elastic parts it is trifling. In inflammation of the scalp, for instance, it is curious to observe that only where the yielding tissues are firmly united with the gristle of the ear, is pain complained of.

The character, as well as the intensity, of pain varies, too, according to the structure involved. Thus, if the pleura covering the lungs is inflamed, the pain is stabbing or darting; in the conjunctiva (the membrane covering the eye), the pain is gritty or itching; burning or gnawing in the lining of the stomach. Throbbing pain, produced by the filling and tension of the arteries with each beat of the pulse, is usually indicative of inflammation, though it may occur in paralysed persons from weakening or diminished elasticity of the blood-vessels. From this cause a permanent flushing of the cheeks is common in palsy, just as blushing is due to a temporary paralysis of the nerves which control the cutaneous circulation.

Although, as already hinted, the existence of extreme pain cannot be taken as an evidence of the severity of a disorder,—for pain of the most acute character occurs often without any other evidence of disease (being itself the disease), and passes away, leaving no traces of alteration or change of structure in the painful part,—yet pain is of great value to the physician as a sign or symptom of disease, indicating to him by its situation the organ affected, and by its character and intensity the nature of the complaint. But it should be borne in mind, that though of real value in assisting diagnosis, pain is a symptom very apt to mislead. The seat of pain is not always that of the disorder whence it originates; an irritating cause may be either at the source, or along the course of a nerve, or at its termination, and yet be felt at the same spot. Tic-douloureux may be caused by disease of the bones of the head pressing on a nerve where it passes through the skull. Discomfort in the stump of an amputated limb may be referred to the parts which have been removed, as in the case of the old sailor who constantly complained of a pain in the toes, though he had lost both his legs at the battle of Trafalgar. Pain in the knee is common in hip disease; in the shoulder, from disordered liver; in the arm, from heart affection; and in the larynx, from accumulation within the lungs. Pain, too, often occurs long after the cause to which it is due has passed away; and if this fact were more generally realized, we should be better able to avoid what is harmful. Muscular stiffness is often greatest two or three days after the exertion which gave rise to it, and the same is true with regard to headache arising from overwork. Still more is this the case with other common forms of "sick-headaches," which, having no direct and immediate relation to the food last taken, are confidently asserted to be entirely independent of the digestive organs. In searching for the cause of a morbid condition, we shall be less likely to be misled if we bear in mind that this interval (between the pain itself and its exciting cause) may be, especially in persons of feeble organization and slow circulation, greatly prolonged. Pain in a part, even when purely subjective in its origin, may produce not a semblance merely of actual disease, but real alteration in the structure, though previously healthy; for the direction of the attention to any organ is a cause of the determination of blood to the part; inflammatory action may follow congestion, and may pass on to disorganization.*

Internal organs, the lungs especially, sometimes become diseased in consequence of the habitual direction of the consciousness to them. Not only is pain an active agent in the production of disease, but it is sometimes an actual cause of death. Its influence in diminishing the action of the heart is immense, producing that extreme degree of depression, or collapse, from which the patient never rallies. When we speak of death from "shock," it is sometimes the pain which, inducing the shock to the nervous system, must be looked upon as the destroying agent.

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* The late Sir Benjamin Brodie recorded a number of cases of affection of the joints following hysterical concentration of the mind on the part.

Hence we are naturally led to consider the treatment of pain, and cannot fail to see the importance of sound views as to its origin and nature. If pain were due to an "excess of life," then it might be a right practice to attack it with lowering remedies; but since it is really dependent on deterioration of the vital processes, our aim must be to restore rather than to destroy, to build up rather than to pull down.

On the first suggestion of pain, our impulse is at once to fly to the nearest remedy: that which shall the most speedily and effectually secure to us the much-desired relief. It may be interesting to point out the action of some of the means usually adopted to attain this end; and a word of warning against their abuse may not be out of place.

The power of tea and coffee in relieving nerve pain is particularly striking; and the influence of quinine and strychnine is, in a certain sense, analogous. The former, as well as the latter class, of remedies, may be taken in poisonous doses. Brandy and other powerful stimulants often act by a sort of revulsive influence.

Since one form of disease may counterbalance and counteract another, it is sometimes justifiable to develop an artificial source of disturbance, and it is upon this principle that blisters, setons, and issues, etc., act.

Chloroform, like cold or galvanism, causes contraction of vessels, renders the brain pale, and thus destroys consciousness. Narcotics, opium, tobacco, and the like, retard oxygenation, and check vital processes. Local anæsthetics, as ice, or æther spray, by freezing the part to be operated upon, deaden its sensibility; and though thus annihilating pain, they yet leave the patient fully conscious, and alive to the feelings of horror consequent upon his seeing the operation in progress. Other means of temporarily destroying the sensibility of the nerves to pain there are, such as opiates taken internally, or syringed under the skin of the painful part, and they are of great value. But it must be borne in mind that the removal of pain is not necessarily the removal of the disease.

The deadening of pain by opiates may gain for the doctor the delightful applause of the sufferer, although not unfrequently the benumbing of sensation is the first step in the course of hopeless retrogression. It is this benumbing influence of sedatives which make them often so injurious; they induce an artificial calm, and say "Peace, peace, when there is no peace." It is as unwise thus to silence the voice of nature, as to deal heedlessly with the complaints of the body. By a merciful provision, it frequently happens that nature herself supplies the means whereby the sufferer is enabled to bear up though enduring the most racking pain. Under the influence of intense excitement, or mental emotion, the balance of the nervous system is sometimes so completely destroyed, that during great injury of sensitive structures no pain is experienced. This absence of pain after wounds, which would otherwise entail suffering of the most intense character, is often remarked upon the field of battle. Dr. Livingstone's account of his rencontre with the lion, when his arm was fractured, illustrates this fact: he writes, "I saw the lion in the act of springing on me. I was on a little height; he caught my shoulder as he sprang, and we both came to the ground below together. Growling horribly close to my ear, he shook me as a terrier dog does a rat. The shock produced a stupor like that which seems to fall on a mouse after the first shake of the cat. It caused a sort of dreaminess, in which there was no sense of pain nor feeling of terror, though I was quite conscious of all that was happening. It was like what patients partially under the influence of chloroform describe, who see all the operation, but feel no knife. This singular condition was not the result of any mental process. The shake annihilated fear, and allowed no sense of horror in looking round at the beast." This peculiar state is probably felt in all animals killed by the carnivora; and if so, is a merciful provision by our benevolent Creator, for lessening the pain of death.

Livingstone remarks that, "besides crushing the shoulder-bone into splinters, he left eleven teeth wounds in the upper part of my arm,"—a wound which, but for the fascination described, must have been an acutely painful one.

At a recent railway accident, such was the excitement of the moment, that a gentleman, five of whose ribs were broken, was observed to disentangle himself from the broken carriage, lift his wife, by no means a "light weight," and lay her on the embankment, ignorant of the injury he himself had sustained; whilst a little boy, whose leg was badly broken, crept through the broken window, and trying to walk, found he could not stand, for his leg was "limp like a doll's."

Not only is the cessation of pain in acute disease often a sign of ill-omen, but the absence of pain in disorders which are usually intensely painful—pleurisy, for example—is frequently a serious evil; partly, no doubt, because the malady may thus run its course unobserved, without any steps being taken to check it. When the natural sensitiveness of a part becomes destroyed, disease often progresses with great rapidity. In some kinds of paralysis a particle of dust falling on the eye gives rise to no sensation of grittiness or pain, as would be the case in a healthy condition, but sets up irritation, which frequently results in the destruction of the organ. In paralysis,* again, one position is often retained until the vitality of the part is weakened, and thus "bed-sores" form; whilst in health a sensation of discomfort leads us at once to shift our position, and this almost without our noticing the discomfort, or the change of posture. Between discomfort and pain we can draw no line, the one passing insensibly into the other.

It must therefore be evident that pain is, under certain circumstances, really beneficial. It is often a great boon to have a sensitive stomach; for those who suffer pain after food are less apt habitually to err in diet, and thus to become dyspeptic or gouty, than those whose organs receive everything uncomplainingly. Pain in the stomach is frequently due (in well-to-do people) to the fact that they won't work and will eat; not that the stomach itself is weak (as they think), but that the supply of food being greater than the demand, the system becomes overstocked. In dyspepsia the cause is very often far away, and the stomach is no more the cause of the malady than the big toe is of the gout; but if the stomach gave no signs of perturbation, the evil would be allowed longer to exist unnoticed. We should always give early attention to pain, and discover its causes, before they become too complex to be unravelled, and before the derangement which its presence indicates becomes permanent. We must not school the body to bear it under a mistaken notion that resignation, for its own sake, is a virtue to be cultivated, but take steps at once to find out and avoid the cause. Pain tells us that the bodily machinery is out of order, and needs attention; and to nothing does the old adage apply more truly, that "a stitch in time saves nine." In some persons, it is true, there is a tendency to morbid introspection, and much thought may be given to little meaningless ailments; but as a rule it is wise to be ready to detect the earliest evidence of derangement in order that appropriate remedial measures may be at once adopted. When, on the other hand, it has been ascertained that any form of pain denotes no real danger, or that the mischief is irremediable, nothing contributes more at once to manliness of character and to enjoyment of life than to put away as far as possible the thought of the inevitable suffering, and to encounter it with cheerfulness.

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* In hysterical or hypochondriacal people, whose sensibility is very acute, apparent paralysis occasionally occurs, not from loss of power, but from fear to move a part lest motion should give rise to painful sensations.

From what has been said, it appears that we can in no sense regard pain as a needlessly inflicted punishment, for plain evidences of its usefulness are not wanting. In health, but for a wholesome dread of pain, we should, as children, be daily rushing into danger; and throughout life it acts as a continual perservative from harm, preventing the performance of many actions which might entail upon us bodily injury. In disease, again, especially when of an inflammatory type, it serves to secure to us that perfect rest so essential in promoting recovery, and prompts to many necessary actions which we should otherwise neglect.*

Pain also has higher uses even than these. We most of us admit that we are better for wise correction; and if we regard pain as a means of "refining our earthliness," as indeed a "loving correction," then the correction may become "loved" also for its end's sake, and bearing the pain become an easy task; so that we can say in Keble's spirit:—

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* The following extract from the letter of a lady, long a great sufferer, illustrates the influence of pain as a life preserver: "Pain makes me take care now: though the love and desire of life are wholly gone, there remains the same shrinking from increased pain; and so I don't do things I should do otherwise, because they would probably bring on suffering without touching life."

> "Wish not, dear friends, my pain away;
> Wish me a wise and thankful heart,
> With God in all my griefs to stay,
> Nor from the *loved correction* part."

As gold is purified in the furnace, so is character refined by pain. Nor is this merely a modern thought; when the ancient patriarch was wasted by protracted suffering, then it was said, "There is none perfect on all the earth like Job."

All this, however, does not prove that pain is a good in itself. Its beneficial effects in leading us to avoid evil are partial only; often its results are mischievous: nor does it always punish sin, or serve as a discipline to character; for very often it falls upon the innocent most heavily; very often it hardens and rouses to the bitterness of despair, paralysing instead of stimulating. Some deeper reason than any of these must account for its existence in the work of a beneficent Creator.

We have now hastily glanced at some of the prominent characteristics of pain. The subject of pleasure is so intimately associated with it in our minds, that we cannot pass it by without the one remark that it is impossible to draw an absolute line between the two. In some instances, what is to one person painful, is to another, or to the same person at another time, pleasurable. Our pains and pleasures depend to a great extent upon ourselves. The absence of all exertion, unendurable to the healthy man, may be to the invalid essential to pleasure or comfort; the natural exercise of the powers, which ought to be a source of pleasure, may be his agony. Things rightly pleasurable become painful when we lack the power to enjoy them; and on the other hand, without a certain amount of endurance, life ceases to be enjoyable, and work, itself an irksome thing, we find necessary for happiness.

X.

RESPIRATION.

I. THE FLAME OF LIFE.

It has been a favourite comparison of moralists and philosophers to say that the life of man is like the burning of a flame; and, looking at the physical life, not of man only, but of other animals, there can be no doubt that the comparison is true in more senses than could have been suspected by those who first made use of it. For life, like the burning of a flame, is a continuous process, which has no stop or pause. It needs, like fire, to go on with a certain energy and intensity, if it is to go on at all; and, failing this, it fades away and comes to an end, not to be again revived, except new life be given. These points of likeness have always been seen, and it is probably such as these which suggested the image. But there is one other point, less striking at first sight, in which life and flame are not merely analogous, but exactly alike. Neither, as we commonly know them, can exist without the presence of the common air; and, as we shall see, there are other points of likeness which depend on this. It is not, of course, our object here to pursue the comparison very far, but having to speak of that part of man's life called respiration, or, in plain words, of what we have to do with the air—how we breathe it, and for what end—it will greatly help us to start from this admirable comparison. For, in this respect, at least, our life is precisely like the burning of a taper. We need air just as much, we take from it the same things, and we give the same things to it, as a candle, or a fire. But, to make this clear, it will be necessary to say first what it is we mean by burning, and what this has to do with the air.

We have said that a candle cannot burn without air. How is this shown? Since in common life we do not know what it is to be without air, it is necessary to have recourse to an experiment. Let us suppose that we set a taper to burn in some limited space, as, for instance, in a closed glass jar. Lecturers on chemistry do this by fixing the taper on a piece of cork, floating in water, and then inverting a bell jar over the whole. Most persons know what the result is. At first the taper burns as freely as in the open air, but gradually the flame becomes less bright, and at length it goes out altogether. Moreover, in a large jar it burns a longer, in a small jar a shorter time. This shows very plainly that not only is *some* air necessary, but a certain quantity. We shall find, too, another fact well worthy of notice, namely, that the air which remains is altered; so much so, that a fresh taper will not burn in it at all. It would seem then, that the taper has removed from the air all that was valuable, and left behind what it could make no use of.

Now, exactly in the same way, the effect produced by living beings on the air may be examined, and the result is found to be precisely the same. If a small animal, such as a mouse, is shut up in a closed jar, it dies after a longer or shorter time; and it will be impossible for another animal to live in the air in which the first has died. Moreover, as a general rule, it would be found that a candle could not burn in the air in which an animal could not live, and *vice versâ.*

It seems, then, that in these respects the process of life and the process of burning are exactly alike. In each process, a certain part of the air seems to be used up; and since the air which is left is good neither for life nor for combustion, we may suppose that they require and use up the same part or ingredient of the air. Every one who knows anything of chemistry has heard that the air, though it seems to us something quite simple, is really a mixture of two gases or kinds of air. These are known by the names of *oxygen* and *nitrogen.* Oxygen, also called *vital air,* is the active and important element in supporting life and combustion: while nitrogen is a neutral or inactive gâs, which is of no particular account for either of these purposes. If oxygen were removed, though it is only one-fifth part of the whole in bulk, nothing could live or burn. If nitrogen, which makes up four-fifths, were taken away, its absence, though important enough in other respects, would not prevent the processes of life or combustion from going on. It is hardly necessary to say, then, that what a burning candle or a living animal takes from the air is oxygen (though neither takes away, generally speaking, *all* the oxygen), and what is left behind is principally nitrogen.

But there are one or two other points to be mentioned about the air in which things have burned or lived. In the first place, such air is always moist. We know that our breath is moist, that is to say, contains watery vapour, and the same thing may be seen by holding a cold glass above the flame of a candle. In the second place, such air always contains a peculiar gas, or kind of air, called *carbonic acid,* or *fixed air.* This is indeed to be found in the atmosphere at all times, but in very small quantities, only about four parts in ten thousand. It is the same gas which in mines is called *choke-damp,* which is met with at the bottoms of wells and in brewers' vats; and is in all these cases known to be so dangerous and deadly. It is always contained, as we have seen, in the air in which any living animal has been, or a candle has burnt; and it is the presence of this gas, quite as much as the want of oxygen, which prevents other things from living or burning in the same space.

In these respects, then, at least, life and combustion are precisely alike: that they take from the air oxygen or vital air, and they add to it moisture and the deadly gas called *carbonic acid.* So far, every living thing has a fire burning within. It seems strange that, in this point, all living things should be the enemies of each other. We are each one of us continually taking from the air what our fellow-creatures need, and adding to it what is poisonous to them. The competition would be terrible indeed were vital air not bestowed in such inexhaustible profusion; and serious indeed would be the wrong done by one creature to another, were there not means at hand for dispersing the deadly poison which all produce, and rendering it harmless. In the open air no creature ever suffered from want of oxygen, or from too much carbonic acid; but in crowded rooms and unhealthy dwellings, serious harm may be caused by the excess of the one, and possibly also by deficiency of the other. Of this, however, we shall speak by-and-by.

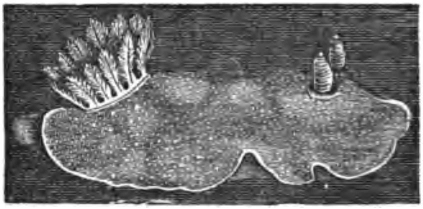
II. THE MECHANISM OF BREATHING.

We have said that animals are continually taking from the air, and giving to it, certain gases. We shall now say something about the mechanism or apparatus by which those gases get in and out of the body.

In the first place, we must say that the gases always pass through a moist membrane or delicate skin, and always pass into or out of the blood. This is the one thing necessary. There must be in every organ of breathing a delicate moist skin, which permits air of different kinds to pass through readily, but nothing else to pass in or out. Such a membrane as this, on one side of which is the blood, on the other side the air, may be called the *breathing-membrane.* In the simplest animals the whole of the skin serves this purpose; they breathe all over their bodies. But in more complicated animals one part only of the general covering is set apart for this purpose. Just as in a simple state of society every man is a soldier, a husbandman, a shepherd, a tradesman; but in civilized societies one man has, as a rule, only one trade· so in simple animals any part of the skin may be used for any purpose—for taking in food or for taking in air; but in the higher animals one part is devoted to one purpose and one to another.

Now the breathing membrane of animals is arranged in various forms. It may line a hollow place communicating with the outside, as in the lungs of air-breathing animals, or it may be stretched over a projecting portion of the body, as in the gills of fishes and other water animals. The sea snail in Fig. 1 breathes by the delicate tufts on his back, which are covered by what we have called the breathing-membrane. Water animals do not really breathe water, but the air which is dissolved in it. If you boil some water, so as to drive all the air out, and put a fish in it, he will be just as badly off as a fish out of water. So that the breathing of water animals and land animals is really the same process. The fact that an animal possesses breathing organs does not prevent some breathing taking place through the ordinary skin. Animals with moist skins, as frogs, breathe a good

Fig. 1.



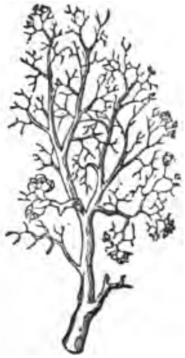
DORIS, OR SEA SNAIL.

The crown of tufts on its back, which is covered with a delicate membrane, is its breathing apparatus. (After Carpenter.)

deal in this way; and even in ourselves a certain amount of gas is given out through the skin, though it is doubtful whether any air is absorbed. At all events, the chief amount of breathing is done by the special breathing-membrane which lines, as we have said, certain organs called *the lungs*.

Our lungs, as most people know, are situated in our chest, and air is conveyed to them through a pipe in our neck, called the *trachea* or *windpipe*. Now, the windpipe divides into two, sending a branch into each lung. These branches divide into several others, called *bronchial tubes*, and these into still smaller bronchial tubes (Fig. 2). Finally, the smallest bronchial tubes

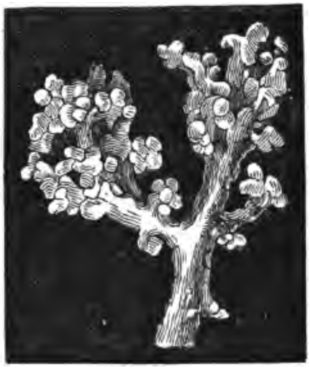
FIG. 2.



CAST OF ONE OF THE TERMINAL BRANCHES OF THE BRONCHIAL TUBES FROM THE HUMAN LUNG.
Natural size. (After Henle.)

end in a very small funnel-shaped cavity, at the sides of which are several saucer-shaped spaces, called *air-cells*. Fig. 3 represents a plaster cast of some of these funnel-shaped terminations, with the air-cells upon them. Thus the whole system of tubes is like a tree, of which the windpipe is the trunk; and the air-cells are, roughly, like fruit or leaves growing on the smallest twigs. Each twig, or little bronchial tube, with its group of air-cells, forms a hollow space, like a glove with the fingers distended, and does not communicate with the others, but only opens into the larger air-tubes. This will be understood by Fig. 4, which represents a lung before it is completely formed.

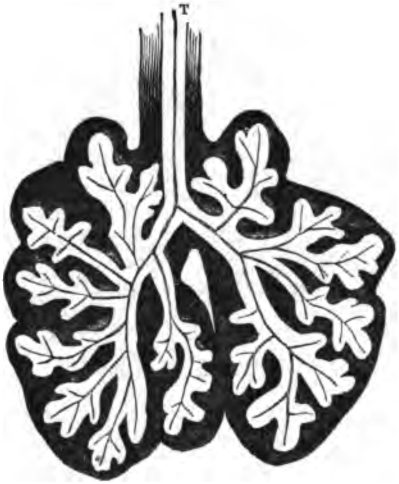
FIG. 3.



SMALL PORTION OF THE SAME CAST AS IN FIG. 2.
Magnified 15 diameters. (After Henle.)

Here the air-tubes are seen to be hollowed out in the solid substance of the lung. As the lung grows, these become a hundred times as numerous, and are so closely packed together that the solid substance becomes almost nothing, and the lung appears porous, like a sponge. But really it is made up of nothing but air-cells and tubes arranged as we have described them, and forming one cavity which communicates with the outside air only through the windpipe.

FIG. 4.

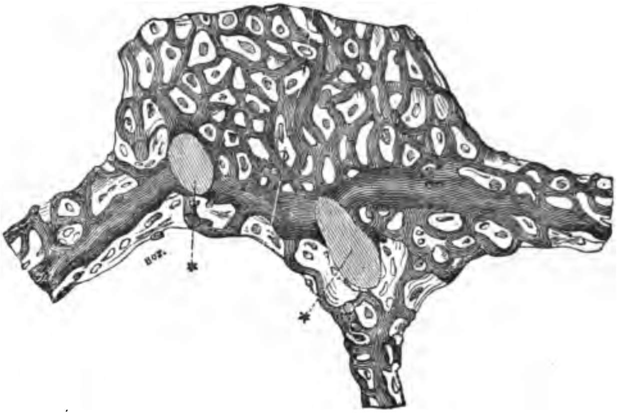


HUMAN LUNG AT A VERY EARLY STAGE OF GROWTH.

Showing the plan on which the perfect lung is formed. T is the trachea, or windpipe. (After Ecker.)

The membrane lining this cavity is the breathing-membrane, and its whole extent has been calculated as from 10 to 20 square feet; so that if we imagine a sheet 3 feet long by 4 or 5 feet wide, that will show us by how large a surface air is constantly entering and leaving our body. We said just now that the breathing-membrane must have air on one side and the blood of the body on the other. We have seen how the air gets to it. Let us now speak of the blood. If we examine the wall of one of the air-cells we find that many very small blood-vessels, called, from their size, *capillaries*, or hair-like tubes, are

FIG. 5.



NETWORK OF CAPILLARY BLOOD-VESSELS ON THE MEMBRANE LINING AN AIR-CELL.

* * Small arteries cut across. Magnified 300 diameters. (After Henle.)

spread over it. They are so closely placed that (as we see in Fig. 5) they occupy more space than the intervening parts. Imagine the sheet we spoke of just now covered with a network like this, and we shall get some notion of the distribution of blood in the lungs. These little vessels are in connection with larger vessels called *arteries*, which start from one main stem, called the *pulmonary artery*, which begins in the heart. At every beat of our heart, blood is sent through the pulmonary artery into this wonderful network of vessels, whence it returns by another set of vessels, called *veins*, to the heart. It is calculated that $\frac{1}{27}$ of all the blood in our bodies passes at each stroke of the heart into the lungs; so that after twenty-seven strokes, or, on the average, in twenty seconds, the whole mass of blood has passed over the breathing-membrane and been exposed to the action of the air.

The lungs are inclosed in an air-tight box—viz., the chest, which may be made larger or smaller by the movements of its floor and walls. The floor of the chest is a muscular plate called *the diaphragm*, or *midriff*, which is not flat, but arched or vaulted upwards. Every time we "draw a breath," or take air into the chest, this floor becomes flatter and less arched, the consequence of which is that the size of the chest is increased. The walls of the chest, as we know, are made of the bony plates called *the ribs.* These are so arranged that they move upwards, and at the same time project farther from the backbone, and thus the chest becomes deeper in its fore and aft direction. The lungs are not absolutely fastened to the walls of the chest, but their outer surface clings very closely to the walls by suction; so that if the hollow of the chest becomes larger, the lungs, being made of a substance which is extremely elastic, swell up and become larger in proportion. If, then, we want to draw breath, the floor of our chest moves down, the walls move upwards and outwards, the lungs expand, and a certain amount of air is drawn into them through the windpipe. When this effort, called *inspiration,* or breathing in, is over, the chest walls fall back to their former position by their natural elasticity, and as much air as was drawn in is now expelled. Thus the movement of breathing in is a distinct effort, and the movement of breathing out is not, as a rule, an effort at all; but we can increase its force, if necessary, by some voluntary exertion.

As might be expected, not all the air in the lungs is changed with each breath. The amount drawn in and driven out again is calculated to be not more than $\frac{1}{10}$ of what the lungs contain, the actual quantity being from 20 to 30 cubic inches. The air, when drawn in, cannot, of course, penetrate at once to the inmost parts of the lungs, where the air-cells are; but it mixes with the air contained in these parts, and thus that which is breathed out again, though about the same in quantity, is very much altered in properties. It is both hotter and moister, and the gases it contains, are in different proportions. The vital air is, as we might expect, less in proportion, but the carbonic acid of which we have spoken is enormously increased. Breathed air contains a hundred times as much carbonic acid as ordinary air,—containing four parts in a hundred instead of four in ten thousand. It is plain, then, that the use of the lungs is to take up air for the use of the body, and to send out the gas which, as we have seen, is always produced by life or by burning; we must not, however, suppose that the process of burning takes place especially in the lungs. The air absorbed is conveyed by the blood to every part of the body, and the carbonic acid given out is, in the same way, collected from every corner to which the blood penetrates.

III.—VARIATIONS IN AMOUNT OF RESPIRATION.

Having, then, said something about the machinery by which the process of breathing is carried on, we now propose to consider the amount of breathing which goes on under different circumstances, and the rules for practical life which may be drawn from these facts. The most elaborate and extensive experiments have been made to measure the quantities of gases absorbed or given off under different circumstances; and it will perhaps be interesting to give some account of some of the ingenious and beautiful apparatus by which these results have been arrived at.

We shall confine ourselves to describing the most perfect apparatus yet contrived—that erected at Munich by the wise liberality of the late King of Bavaria, and now in operation under the guidance of Professors Pettenkofer and Voit. The principle of this is to determine the exact amounts of oxygen consumed and carbonic acid given out by an individual living under ordinary conditions, and with whom it is therefore possible to carry on the experiments for many hours at a time. The way in which this object is effected is as follows:—

A little sheet-iron chamber, about eight feet in each direction, is devoted to the individual who is the subject of experiment: in it he can live, eat, and sleep with tolerable comfort for twelve or twenty-four hours. In one side of the chamber two pipes are fixed, about three inches in diameter, which unite a little way off, and through which air is continually pumped out of the chamber by steam-power. There is an opening on the other side for the entrance of air, but this is not wanted, that which finds its way in through the crevices of the door and windows being sufficient. In this way a continual strong current of air is drawn through the chamber, so that on an average 70,000 gallons pass through in one day. The air which is thus drawn through has to be measured, and also to be analysed, in order to ascertain the exact amount of oxygen, carbonic acid, and watery vapour which it contains. The air is measured by being made to pass through an ordinary English gasometer, and a portion only is withdrawn to be analysed; this portion being, of course, also measured, and the quantities of these substances contained in it being ascertained, it is, of course, possible to calculate how much is contained in the whole mass of air. The sample analysed is not, however, more than $\frac{1}{2,000}$ of the whole. It will thus be seen that the results obtained do not show the proportion of particular gases in the air inspired or expired, but the absolute amount of oxygen consumed, and of carbonic acid generated, under particular circumstances. A little consideration will show why this is so important a matter to determine. It is very much like, though not exactly the same thing as, weighing the coals burnt in a furnace. It is like that, or comes to the same thing, because, when anything is burnt, the amount of material consumed is exactly in proportion to the amount of air used up. If, then, we could measure the air consumed by a steam-engine, it would be the same thing as measuring the coals, and would equally tell us the amount of work performed. Now this is just what we do with the animal body. We measure the amount of air it uses up, and the carbonic acid produced, and find that this tells us precisely what amount of work it does or can do. So exactly does this process correspond to determining the amount of fuel burnt up in a fire, that when some candles were burnt in the Munich apparatus, the weight consumed could be, it was found, precisely calculated from the gases produced.

We must here say a word about the one point in which the comparison of life to combustion does not entirely hold. In combustion, the amount of air used, and the amount of the often-spoken-of carbonic acid produced, are, for any period whatever, exactly equal in bulk. In the living animal, this is not the case, if the observation is made for a short period of time only; sometimes the one seems to be too much, sometimes the other. If, however, the quantities of both in twenty-four hours are determined, they are found to be pretty nearly equal; the oxygen being constantly rather more; since it is, in fact, used in the body for other purposes besides burning up material to form carbonic acid gas. With this exception, the processes are in the long run the same. Now, it has always been suspected that the body possessed some power of accumulating oxygen for future use, and some experiments lately made with the great Munich apparatus have thrown much light upon this point. It has been found that, speaking generally, we absorb more oxygen during the night, and produce more carbonic acid during the day.* In other words, we store up in the hours of sleep that vital air which we need for the hours of toil. Moreover, as the amount of carbonic acid produced always bears some kind of proportion to the work done in the day, so, after a laborious day, it was found that the process of absorption was also active just in proportion. This certainly explains better to us the uses of sleep than any facts hitherto known. As the production of carbonic acid is more especially a process belonging to the day, so it is accelerated by all occupations which belong to the day. The quantity increases with exercise, it increases after taking food. It has been noticed, too, that in cold weather much more of this gas is produced than in warm weather, and more when moist air is breathed than dry air. We should not suppose, as people often do, that fresh air is less needed in winter than in summer. As might be expected, the amount of this gas produced is greater also in proportion to the size of the individual; but it is curious that this seems to depend more upon muscular development than height, or even the capacity of the chest. Grown persons produce naturally more than children or old people, but children produce more in proportion to their weight.

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* Later experiments have thrown some doubt on this statement. It has been found that the hours of taking food much affect the result. Still something always remains which is due to the difference of day and night.

We have spoken of some of the conditions under which the great fire of the animal body is kept up. A few words may now be said about one result commonly associated with burning, and, as we shall see, also associated with the flame of life—that is, the production of heat. It is certain that the heat of the animal body is simply owing to the burning which is continually going on inside it. This production of heat doubtless takes place in all parts of the body, and not only in the lungs, so that no one organ can be spoken of as if it were the furnace of the whole system. Rather the whole body is one great furnace.

It is tolerably certain that most, if not all, of the great operations or functions of the body cannot go on without some kind of combustion. The muscles contract, the nerves transmit sensations or the commands of the will, the stomach digests, the brain acts in thinking; in all these cases, some kind of chemical process is going on which requires the presence of vital air, and which resembles in some degree the process of burning. If this be the case, how important it must be that there should be no impediment to perfect combustion, that not only the supply of fuel, but the supply of air, should be sufficient!

With the fuel we have at the present moment nothing to do. That stands for food in our comparison. But just as coals will not burn unless there be a good draught, so it is certain that food will do us no good without a proper supply of fresh air. People are very willing to admit this in words, but they do not always think about, or perhaps know, what pure air is, and how it is to be obtained. No one doubts that the air of the mountain-top or of the open fields in a healthy country is pure. If we could only get enough of that, we should do very well. But the air some of us have to breathe is not so good as this; and we do not always get enough of it. There are very many impurities met with in air; but we must confine ourselves here to those arising from the process of breathing itself; in which, as we have seen, men are always tending to poison one another. A man breathes out on an average twelve cubic feet of air in an hour; and this air contains, as we have seen, 100 times as much carbonic acid as ordinary air. In order, then, to dilute this, and to bring it to a condition in which it is fit to breathe again, it should be diluted with one hundred times its bulk of pure air. Since ordinary air contains, as we have said, a certain proportion of this gas, it will be necessary to have double this quantity in order that the products of respiration may be rendered at once perfectly harmless. This would give 2,400 cubic feet per hour as the quantity of fresh air necessary. Since, however, there is a great deal of imperceptible diffusion of air, it is quite safe to say that 2,000 cubic feet per hour for each individual would be sufficient. This number agrees very closely with those obtained by different observers by various methods, and is, moreover, the same as that arrived at after careful experiments as to actual ventilation of rooms.

This will, however, convey but little practical information if we do not know what size and arrangement of openings there should be to secure this amount of air. It is calculated that if nothing but natural ventilation is made use of, that is to say, the natural movements of hot and cold air, an opening five inches in the square will admit this amount of air in an hour; at the same time there should be an equal opening in another position for escape of the impure air. The outlet should naturally be near the top of a room, and the inlet near the floor. To take an instance: suppose that a room is to be ventilated entirely by means of a window four feet wide. If this were opened rather more than half an inch at the bottom and the same at the top, we should get two openings of the required size; that is the very smallest amount sufficient to destroy the bad effects of the breathing of one person. If two persons are present, each opening should be twice as large, and so on. This implies that the window must be thus open day and night, quite independently of opening the doors and windows from time to time. Of course, it is not in all seasons possible to keep windows open, and then we must have some other method. The one most readily at hand is the fireplace. Since there is here an additional force at work, namely, the heat of the fire, we can, to a certain extent, dispense with an inlet, for the draught will suck air in for itself through crevices and chance openings, but it is much better that these should be provided. An ordinary chimney is seldom more than one foot square in the shaft, often not more than eight inches. Now, a shaft eight inches square gives ventilation sufficient for about three men, on our scale, certainly not more. So that if more than that number habitually live in a room, some other means of ventilation is necessary.

We give these numbers as the least possible consistent with proper removal of the ordinary products of breathing; but how many other sources of impurity are there! Take simply gas-burners, or even other lights. It has been calculated that an ordinary gas-burner requires, to remove entirely all the impurities produced, about 5,000 cubic feet in an hour, or 2½ times as much as a man. We must then reckon two gas-burners as equivalent to five persons in the amount of ventilation they require. A moderate-sized oil-lamp or a candle only contaminates the air one-tenth as much as a gas-burner.

It must be evident that very few rooms are constructed to change the air as much as, on these principles, it should be changed. In ordinary sitting-rooms, where but few people remain at one time, and where the doors are frequently opened, the fireplace in winter, and open windows in summer, are quite sufficient. But what can be the state of workshops, schools, law-courts, theatres, concert-rooms?—what of churches and chapels? It is plain that scarcely any at all approach the proper standard. In buildings used only for an hour or two, the deficiency may be pardoned; but what is to be said of workshops and factories, where many live for long hours, and are besides hard at work; thus producing, as we know, with all the more rapidity, substances which contaminate the air?

The day will come, let us hope, when people will look back with astonishment and horror on the cruel ignorance of the present day.

Look again at sleeping-rooms. We know that though the air is less contaminated during sleep, there is all the greater need of oxygen; since, too, there is no opening of doors, or going in and out during the night, there should be all the more care taken to have a constant change of air. Yet people will shut up every crevice in a small bedroom, and go to sleep, flattering themselves that if it is warm it must be healthy.

Closely connected with the question of the supply of fresh air is that of the size of rooms. The amount of space allowed to each man in barracks is now 600 cubic feet, and in hospitals twice that amount. This is equal to a small room measuring 8½ feet every way, in height, width, and length. There is little doubt, however, that it should be more, and 800 feet would not be too much. This gives a room eight feet high, and ten feet in each of its other dimensions. These numbers apply especially to sleeping-rooms, but quite as much space is necessary in day-rooms, if they are occupied for many hours together, as are workshops or schools.

So far are ordinary buildings from fulfilling these conditions, that we must be prepared for a little incredulity as to the necessity for them. It may be said that if this be the case, no one can be in good health. Now the real state of the case probably is, that well-to-do people living in good-sized rooms, which are very rarely crowded, do not, as a rule, suffer from insufficient supply of air; but in the crowded dwellings of the poor, and quite as much in shops, milliners' workrooms, and so forth, the amount of disease and ill health thus produced is enormous. One good instance is worth a hundred statements of opinion; and so we will just quote authentic documents relating to the prevalence in the English army of certain diseases—as, for instance, consumption—which are known to be especially encouraged by impure air. In former years, barracks were built without any regard to the health of the soldier, and combined almost every possible deficiency in the supply and distribution of fresh air. Since the year 1859, an entirely new system has been in force. The new barracks are built with a proper regard to ventilation, and the old ones have been much improved. The effect in the general mortality, and especially in diminishing the ravages of this class of diseases, is most extraordinary. Formerly, consumption and similar diseases caused more than half the whole number of deaths; the proportion is now just about one-third. When we take into account the fact that deaths from all diseases in the army are scarcely half as numerous as formerly, the gain to human life will seem still more extraordinary. All European armies formerly suffered much in the same way, and some do so still; but in most similar reforms have lately been introduced. It should be remembered that these facts refer, in the case of the English army, not only to cities and unhealthy stations, but to some of the most splendid climates in the world, where the only circumstance tending to produce consumption was the bad construction of the barracks. This instance is quite enough to show that active habits and sufficient food and healthy climate are not enough to prevent such diseases, if the rooms in which we live, and especially those in which we sleep, do not give us a proper supply of air to feed the ever-burning fire within us.

Many experiments in ventilation have been made of late years, with more or less success. Till, however, architects treat the question as one of the first importance, and make arrangements for the admission of pure air when they plan the construction of the building, nothing is so effectual as the simple expedient of a bar of wood, which prevents the entire closing of a sash, thus admitting air upwards in the middle of the window without risk of draught, as explained in the chapter on Ventilation.

XI.

TAKING COLD.

To say, "I have taken cold," or "I have caught cold," is, in strict language, inaccurate. In the first place, natural philosophers tell us there is no such thing as cold; it simply implies in an arbitrary manner a low degree of heat. An atmosphere which feels cool to some persons is not so to others. In the next place, by taking cold, one intends to express that the body is affected by a definite set of symptoms, for which the phrase is not appropriate.

We do not say, "I have taken heat," or "I have taken damp," although these influences produce disease as well as cold. Nevertheless, the expression in question is sanctioned by usage, and is well understood, since every one in his own person has experienced the symptoms which go to make up the condition of having *a cold.* The affection is termed *a cold* because no cause develops it more frequently than sudden or prolonged exposure to a low temperature when the body is insufficiently protected.

To understand how this happens, it will be necessary to remind the reader of the structure of the human skin. Every square inch of skin is perforated by several thousand openings, which are the apertures of corresponding glands by which the perspiration is separated from the blood. The quantity even of the insensible perspiration is very great, and it will surprise many to hear that, in the healthy state, it amounts to more than two pints in twenty-four hours. Under the influence of exercise or of unusual heat, such as that of the Turkish bath, when perspiration drops from the body, it is, of course, considerably greater. The skin, owing to its structure, possesses a contractile power in a high degree.

Cold contracts almost all substances, and when the skin is exposed to its influence the contraction becomes visible to the eye, and the appearance it presents is called *goose-skin,* from its resemblance to the natural condition of the skin of the goose. Occasionally the effect of the contraction is to close rigidly the perspiratory pores, by which the escape of the secretion is obstructed. This, so far as we know, is the essential cause of what we call *a cold.* It seems that the fluid, having been checked in its natural outpour, is diverted inwardly upon the mucous surfaces of the body. Between these surfaces, which line all the internal parts which have any connection with the outer air, and the skin or covering of the external parts, there is a close relation, which is sometimes expressed by the term *sympathy*. Thus, it is well known that in many persons certain substances, which act as irritants to the stomach and bowels, cause irritation, and even eruptions, on the skin. Worms in children cause itching of the entrance to the nostrils; shell-fish, cucumber, and many other articles, produce in some persons eruptions on the face. In the latter instances, it may be objected that the noxious agents act by affecting the blood, but in many cases there are reasons for believing that the effect can only be that of indirect, or, as it is scientifically called, *reflected* irritation.

This internal skin, then, or *mucous membrane*, properly so called, is very prone to be affected by causes which derange the natural action of the outer skin. But the mucous membrane is itself provided with glands which secrete its mucus or natural moisture; for in a state of health this, in many situations, such as the nasal cavities, is all that is required, and therefore all that is present. But when the mucous membrane of a part secretes fluid in excess, and a defluxion is established, the affection is termed *catarrh*. This word is a Greek compound, denoting an increased flow; and it is probable that none of the mucous membranes are exempt from its occurrence from some cause or other.

Cold in the head is by far the most frequent result of taking cold, regarded in a general sense. It may be well to describe briefly the symptoms of this common disorder; but it is desirable first to explain the nature of the parts affected.

The interior of the nose consists of a cavity separated into two equal parts by a thin partition of bone, which passes from before backwards, and which is continuous with the fleshy part of the partition seen at the entrance to the nostrils. Attached to the outer wall of each cavity are three thin convoluted pieces of bone, arranged one above the other, and also extending from before backwards. All these bones are covered by mucous membrane, and one use of the convolutions is to increase the surface exposed to the air, so that the odoriferous particles or vapours may thus affect the nerves of smell, which are distributed over the membrane. Now these cavities of the nose, besides other connections, communicate with the mouth and throat behind, and above with certain cavities in the front of the skull, which act as sounding-boards in giving clearness to the voice; and these cavities are also lined with mucous membrane.

The first symptoms of cold in the head are a sense of tightness or fulness in the nose and forehead, corresponding with the position of the cavities in the skull already described. The person sneezes, and his eyes become suffused. There is a general sense of discomfort, and disinclination for exertion. The skin is dry, and the pulse a little quicker than usual. The patient is, in short, somewhat feverish. If the interior of the nose be now examined, its surface will be found hotter and drier than natural; it looks redder, too, and tumid, from containing an excess of blood. The tumidity of the mucous membrane causes a sense of obstruction to be felt, and the voice is frequently affected from interference with the free connection between the nose and the frontal cavities. After this state of things has continued for a day, or longer, moisture begins to exude from the mucous membrane of the nose. This moisture is often at first thin and clear, like water; it is not pure water, however, but contains several ingredients, of which common salt is one. It frets and causes a sore eruption on the surface of the upper lip, over which it trickles during sleep.

After two or three days, the nature of the discharge in general alters. It thickens, becoming rather opaque and very viscid. In children, it is now often more or less purulent—that is, yellow or mattery.

Every one knows that although this discharge is inconvenient, and that the use of the pocket-handkerchief comes to be an absolute necessity, it is soon attended by relief. The sensation of tension in the head ceases, the skin begins to resume its proper functions, and the slight disturbance of health gradually lessens. But the time in which a cold in the head runs its course is very variable. Some persons get rid of such a cold in a few days, while others, from some peculiarity of constitution, retain it very much longer. A good deal depends, too, on how it is treated, and certain plans have been proposed by which this troublesome enemy can be more or less successfully combated. Not to mention many medicines, of which one of the most efficient is opium in some form,—but for the use of which it is always better to seek proper advice,—there is a particular method of treatment, once in much vogue, which, although troublesome, is sometimes very successful. It consists in abstaining as much as possible from drinking any liquids. By this means the supply of fluid to the blood, which goes to keep up the discharge, is cut off, and with it the discharge itself. In this way a bad cold in the head may sometimes be cured in a single day.

An equable temperature also conduces towards recovery. It is always desirable in winter to remain a few days altogether within doors, and to keep one's apartment at a constant heat of about 65° Fahrenheit. This gradually induces the skin to perspire, by which its sympathetic friend, the mucous membrane, which has been trying, however imperfectly, to do the work of its neighbour, is relieved from its efforts. Sometimes, and especially at the very commencement of a cold, a forced action of the skin, by which it is made to sweat profusely, succeeds. This may be effected by internal medicines, aided by hot drinks, while the body is well covered with bedclothes. But a far more effectual sudorific is presented to us in the Turkish bath. The patient should expose himself to a heat of from 130° to 150° Fahrenheit for not less than an hour, and in this case the cold douche generally used after the bath should be dispensed with, and tepid water used instead. The object in view is not only to cause the sweat-pores to relax their orifices during the process of sweating, but to remain relaxed afterwards. Cold water dashed against the skin would tend to produce the contrary effect.

Cold in the head was known to our ancestors by the name of *the pose,* and *to pose* is still used in the sense of to stupefy. The term was evidently given to the disorder from the lassitude and indisposition for one's accustomed work which accompanies it. How slowly and by what painful steps knowledge advances! Only two hundred years ago, the real source of the discharge from the head which accompanies a cold was described by Schneider. Before his time, the discharge was thought to come from the brain! In anatomical language, the internal lining of the nose has ever since been termed *the Schneiderian membrane.*

It has been held by certain writers that what is called disease is the expression of a beneficent design, as much as the adaptation of organs to their particular functions. They point to the eruptions on the skin in small-pox and like diseases as being the means adopted by nature to throw off from the blood, which alone sustains life, some noxious element which had gained access to it. They tell us that in other cases in which no curative effort is obvious, it is because of our ignorance in interpreting nature. They assert that when death occurs from disease, it is an accident incidental to the process to which the vital power succumbs. Now, whether this is true in every instance or not—and the proof is at present impossible—it seems in some instances well borne out. In this very case of cold in the head, we see suppressed perspiration, followed by febrile disturbance of the system, together with retention of materials in the blood which should have been thrown out. This is succeeded by a discharge from the nostrils containing the same salts as those excreted in perspiration, which are thus in a vicarious manner expelled from the blood, and this continues until the disturbed balance is restored.

People often say when they have a cold in the head that they have got influenza, and, on the contrary, this is sometimes mistaken for a simple cold. But the two affections are quite distinct in origin as well as in effects. It is true that many of the symptoms are alike in both, except that they are all generally much more severe in influenza. It is commonly attended by headache, discharge from the nostrils, great languor and depression, followed not unfrequently in the aged and the weakly by death. Influenza is, in fact, a very serious and often a fatal disease. It was described more than two thousand years ago by Hippocrates, the father of medicine, himself. Truly an epidemic, many of its visitations to this country in former times can be accurately traced. These are fortunately not very frequent, and have not usually lasted more than a month or six weeks at a time. Many theories have been advanced to account for influenza. Some have attributed it to a disturbance in the electrical condition of the earth and the atmosphere. One authority went so far, from confidence in this view, as to recommend the use of socks made of oiled silk, or some other non-conductor of electricity, as a means of guarding against an attack. Others have supposed it to be caused by some peculiar miasm in the atmosphere, which, travelling over the earth, accounts for the remarkable manner in which, like cholera, influenza passes from one country to another. But these and other theories are altogether deficient in proof. As in many other things connected with disease, we must for the present admit that we do not know its cause, and be content to wait until patient investigation throws light upon our darkness.

One thing, however, we do know, namely, that while the origin and progress of cholera and influenza have much apparent resemblance, both are also capable of being communicated by infection.

There is another affection, far more prevalent than is supposed, which is sometimes mistaken for a common cold. It is curious that many substances which have no effect whatever on people in general, act most injuriously on the air-passages of a few. Thus, some persons are at once affected with sneezing, and other signs of catarrh, whenever powdered ipecacuanha is exposed to the air near them, and even linseed meal sometimes acts in the same manner. But of all the causes which produce this kind of irritation, none is so widely diffused as that which is derived from our hay-fields in summer. It is now pretty generally known that the emanations from hay injuriously affect a considerable number of people in a variable degree. Some complain merely of symptoms like those of cold in the head and eyes, while in others a severe asthma is produced. Whether these effects are due to exhalations, or to minute particles given off by the hay plants, is not certain. Whichever it may be, one plant in particular, the sweet-scented vernal grass, *Anthoxanthum odoratum*, has been accused as the chief, if not the sole, offender in the matter.

It too often happens that the effects of *taking cold* are not confined to the nose and its appendages in the front of the head. This might be expected, when it is considered that the connections of these portions of mucous membrane with others are very extensive. There are minute tubes lined with this membrane, which pass from the inner edges of the eyelids, where their little apertures can be distinctly seen, to the interior of the nose. The use of these tubes is to drain off any superfluous moisture from the surface of the eyes. The nose, too, communicates with the throat, and from the throat other tubes extend to the interior of the ear. All that concerns the ear and its appendages is treated of in its proper place. It is enough here to indicate that this continuity of structure leads to the same affections of the parts concerned. When a cold in the head is severe, it is very apt to affect the eyes; and when the ear-tubes are obstructed from pressure of adjoining parts, which have become swollen from inflammation, deafness is caused.

The mucous membrane of the throat also communicates not only with the gullet, or passage which leads to the stomach and bowels, but by another avenue which descends for some distance by the side of the gullet to the lungs. This is the windpipe, by which the constant renewal of air in the lungs is effected.

It often happens, then, that the inflamed condition of the nose extends to the throat, which is felt stiff and slightly sore in the act of swallowing. The tonsils, or glands which stand out at each side of it, become enlarged. The inflammation is also now very liable to extend more or less into the windpipe. But the disorder does not always advance in this particular manner. Not only are the nose and its immediate appendages sometimes alone attacked, but at other times catarrh affects the throat alone, at others the windpipe only. Now, whenever the latter is affected, we have cough produced in addition to other symptoms.

Cough indicates irritation in the air-passages of the lungs. It is caused by a peculiar convulsive motion, though the same result can be effected voluntarily, by which the muscles of respiration are made to expel forcibly a portion of the air in the lungs. The immediate cause of cough, as is well known, is a sensasation in the windpipe, for which it is the natural relief. Children call it *a tickling in the throat;* and it is a fact no less interesting than curious, that whatever part of the lungs is affected, as for instance when the lower lobe of one lung only is inflamed, the local irritation is reflected, telegraphed, so to speak, always to the same spot. This spot is situated where the windpipe divides into two branches, which go to either lung, corresponding with the root of the neck in front. To this appeal, cough, either as a single effort, or as many efforts constituting a fit of coughing, is the response. In this way the most distant parts of the lungs are relieved, for, as shall be presently explained, coughing is of itself a salutary act.

What a beautiful provision, and clear evidence of design, is seen in this circumstance! Let it only be considered how intolerable would be an irritation in the lungs, deeply seated within the body, if the lungs were themselves possessed of the same kind of sensibility as that which a small part of the windpipe possesses.

It is easy to see that the *use* of coughing is to free the lungs from fluid which would otherwise choke them, and speedily cause death, by interfering with respiration. On the other hand, this outpour of mucus relieves the congested lining of the air-tubes, just as the discharge in a cold of the head relieves the interior of the nose. Anything which is foreign to the air-tubes will produce cough, as well as an excess of mucus. It sometimes happens that such things as a bean, a small bone, or piece of money held in the mouth, gain admission beneath the valve placed at the top of the windpipe for its protection. This produces an intense fit of coughing, and the foreign body has not unfrequently been expelled by this means. One of the most familiar examples of cough produced in this way, is when a portion of our drink *goes the wrong way*. This is invariably attended by a suffocating cough, by which the liquid is thrown out with much force.

We have now explained how a cough is a secondary product of a cold, although the terms are often used to express the same idea. But, in reality, the cough is nature's mode of relieving us from the effects of the cold.

As a cause of disease, *taking cold* has a far wider significance than is implied in its effects as already described. These are the most common, and have therefore been first explained. But in many instances the action of cold is more extensive and far more serious. A chief part of this action consists in the undue abstraction of animal heat. If this be for some time removed more rapidly than it can be supplied, the effects upon the vital organs are apt to be calamitous. Inflammation of the lungs, acute bronchitis, etc., are often thus induced when a man falls into water in winter, or when he has the misfortune to be put to sleep in a damp bed. In such cases the danger is always in proportion to the state of his system at that particular time. If the person be fatigued by want of rest or over-exertion, or weak from want of food, or in any way out of health, the risk is much greater. The reason of this is, that the nervous power by which the circulation of the blood is sustained and controlled is then deficient. And the result is, that the vital fluid retreats from its more superficial channels, and accumulates in the lungs and other internal organs. Congestion—that is, a condition of excess of blood in the parts—ensues, and this is the first step towards inflammation, which, as already said, is in vital organs, under such circumstances, no unfrequent sequel.

Another serious, although seldom fatal, effect of cold, is chronic rheumatism. Repeated checks to the perspiration, and undue abstraction of heat from the body, produce in it a condition of pain and swelling of the joints, which in some instances make life itself a burden. Fishermen, and others, who are liable to have their clothes wet through without the power of changing them, are very subject to this disease.

What are the best means to avoid taking cold? Some may be inclined to say, "Avoid all exposure to its causes; never go out in wet or damp weather; never lie in a damp bed; never become overheated by exercise," etc. Now, even supposing these precepts could all be attended to by people in general, which is manifestly impossible, it will be found that, as often happens, error is here mixed up with truth. It is quite certain such a course would not be the best preventive, because it would inevitably induce a delicacy of constitution that would increase the tendency to be affected by cold. Even in the case of those whose means would permit of it, such a subserviency to the state of the weather, in our damp and variable climate, would become intolerable. We speak of those in good health; invalids must, of course, take exceptional precautions. No sane person would from choice sleep in a damp bed, or remain in clothes saturated with rain longer than he could avoid. But it is in every respect desirable to meet the ordinary emergencies of weather by acquiring sufficient hardiness of body to resist them. It is a great disadvantage to be reduced to the condition of a green-house plant; an exotic in our native country, to which we ought to be acclimatised.

The horse affords a familiar example of how completely the animal constitution may be altered, and indeed impaired, by confinement and well-intended but injudicious care. It is necessary, for the sake of the sleekness of his coat and general appearance, that he should be housed. But his stable is generally much too warm, and is badly ventilated. The result is, that he is very liable to take cold when standing under his master's carriage in wet and stormy weather. Yet horses may be seen standing in the fields, and exposed day and night in all weathers, with perfect impunity.

In the same way as so hardy an animal as the horse is capable of being made delicate by artificial means, is man liable to the same result. The difference in the power of resisting the injurious effects of cold is as great between an effeminate person and a hardy sailor, as it is between a pampered horse and one whose only shelter is a hedge.

The best way, then, to avoid catching cold, although it may seem a paradox, is not to be too much afraid of cold. Let one's accustomed exercise not be interrupted, because it is damp or even rains. Let these conditions be met by appropriate clothing, and let the feet be well protected by strong shoes. This rule must be observed, however; when one is out of doors, and the body feels cold from the clothes having become wet through, it is wrong to remain at rest. The danger of a sudden loss of animal heat has been previously explained, and this loss is then imminent.

Evaporation, although produced by heat, is very productive of cold, and it is greatly promoted by a current of air. It is on this principle that wine is often cooled for the table in hot climates. The bottles containing it are placed in a strong draught of air, while they are covered with a woollen material, which is kept constantly wetted. In this way wine can be obtained almost as cool as by means of ice. Now, in the case of a person whose clothes are wet and exposed to a gale, the conditions are exactly the same; instead of the warm wine, there is the warm body enclosed in a wetted covering. It is to be remembered, then, that the risk of catching cold from wet clothes is always greater in windy weather.

Cold may be taken, however, from moisture retained, as well as by that which is received. When perspiration is profuse, it saturates the inner clothes, and its chilling effects are soon felt if the body is at rest. The best mode of avoiding this is to wear clothes of loose texture in hot and dry weather, so that the escape of perspiration may be promoted as much as possible. Flannel, which has been adopted by cricketers as the most appropriate dress for their active game, is admirably adapted for this purpose. For the opposite reason, waterproof clothing is very objectionable, except when absolutely required to resist rain. Any one who has worn it while taking exercise, will remember the uncomfortable state of dampness which it is sure to induce.

Many persons are extremely susceptible of cold from getting the feet wet or even damp. Fortunately it is in their power to guard against both by simple means; cork soles are very valuable preventives so far as concerns the bottom of the foot, and stout leather will insure sufficient protection for the remainder; but woollen socks, as being the best non-conductors of heat, and withal the least liable to retain perspiration, are in such cases indispensable.

When the lungs are delicate, and especially if a person has suffered repeatedly from bronchitis, the mere contact of cold air with the air-passages, even when he goes from a warm apartment into one of lower temperature, has sometimes an injurious effect. In such unfortunate cases it may be necessary to submit to what is inevitable, and to wear a respirator when out of doors. The apparatus is so constructed that the entrance of air by the mouth is delayed, owing to its passage through a succession of close gratings of wire. In this way the air becomes warmed before it is taken into the lungs. In cold foggy weather this is especially useful. But we are convinced that the instrument is often unnecessarily employed. In such cases its use only tends to bring on the state of artificial delicacy already spoken of. Besides this, if the respirator be put aside even for a minute, as must happen to those who have business to transact, which requires the person to speak, the cold air then gaining access is more liable to irritate the lungs than if no precautions at all had been taken. The nose is, in fact, the natural respirator. One of the uses of its extended surfaces and tortuous passages, is to warm a cold atmosphere before its admission to the chest. Catlin, the traveller, to whom we are indebted for so much knowledge concerning the fast-vanishing tribes of North American Indians, published a small work, which he called "The Breath of Life." He observed that the Indians are above all things careful to breathe through the nostrils. He was so much struck by what he saw and heard amongst them in reference to this matter, and its importance to health, that he thought it worth while to write a book on the subject.

There is a popular prejudice concerning the evil effects of night air, about which a word must be said. In her admirable writings on hygiene and the management of the sick, Miss Nightingale has done much to correct this mistake. It was formerly the universal belief that the air of night was very injurious. But the fact is, that, except under certain circumstances, it is as healthful, or even more so, than that of the day-time. The night air of large cities such as London, when the bustle and commotion, which cause it to be loaded with dust particles, is comparatively quelled, and the numerous fires which contaminate it with their smoke are mostly extinguished, is purer than that of the day. Nothing conduces more to healthy sleep than good ventilation, and no mode of ventilation surpasses that obtained by opening a window at the top, by which the influence of draught is avoided, while the upper stratum of air in the room, to which impurities ascend, is constantly renewed.

There is still another reason for at times adopting night, even in preference to day, ventilation. In sultry weather it is a common mistake to open the windows instead of keeping them altogether closed, as is the case in hot climates. A little reflection will show that since the height of the thermometer in the sun always greatly exceeds that shown at the same time by another thermometer placed in the shade, by opening the windows we admit air much heated into our rooms. The proper time under such circumstances for ventilation is during the night, when the external atmosphere has cooled down. By adopting this plan in hot weather, the temperature of a room may always be kept several degrees lower than if the opposite course is pursued.

The influence of a draught in giving cold is sometimes exaggerated. It is seldom, indeed, advisable or even safe to remain long exposed to a strong current of air. But many persons are so much afraid of even a gentle current, that they deny themselves the advantages of ventilation. In considering the effects of a draught, two things are important. First, the temperature of the current of air. A cold current removes the animal heat unduly, and if it strikes the body in a particular part, not unfrequently causes local rheumatism. But the current will be innocuous if it be only warm enough. In the tropics, so far from avoiding, people try to get into draughts. Arctic voyagers tell us that it is only owing to the extraordinary calmness which prevails in the polar regions, that the extreme cold can be endured. Under the influence of a high wind, the most robust would soon succumb. Here is a striking proof that the constant renewal of the air, when of low temperature, in contact with the body, very much increases its cooling effect. But if the atmosphere is itself as warm as the body, or nearly so, no harm can result.

Secondly, a draught through a small aperture is more dangerous than a more diffused one coming through a larger space. A Portuguese proverb says, "If you catch a cold from draught through a key-hole, you should make your will." A small current of air is the most rapid, and it is unnecessary to repeat the reasons why this is most likely to give cold. We are no advocates of the water-cure, or so-called hydropathy, indiscriminately applied. But it is the part of a wise physician to select from every system that which seems to him useful and true. Hydropathy has at all events made one thing popular, namely, that people do not necessarily catch cold from sleeping in wet bandages or even wet sheets if proper precautions are adopted. These precautions consist in placing a sufficient amount of dry clothing over that which is wet to prevent any chilliness from being experienced by the patient. Here is a principle not to be lost sight of; should it be one's misfortune to meet with a damp bed under circumstances in which no other is to be had, let all available coverings be placed over it, or at least to the extent that the person who occupies it shall feel warm and comfortable. He may then defy the damp, and sleep in security.

In another part of this work a description is given of the Turkish bath and its uses. It only remains here to add, that perhaps no means of hardening the body against liability to taking cold is more valuable than the hot-air or Turkish bath. We have proved this practically in numerous cases. Nor is it difficult to understand how this is effected. The apertures of the sweat pores are thrown open by the high temperature of the bath, and while in this condition are suddenly, but only for the instant, closed by the cold-water douche with which the process of the bath ends. A bracing effect is by this means produced in the skin and its pores, by which the tendency to a more permanent contraction is prevented. No danger need ever be apprehended from the application of cold water, or even, as practised in Russia, of snow to the naked body, if it be made immediately after remaining some time exposed to a high temperature. If, then, the cold-water cure has taught us one important fact, at which probably we should not otherwise for a long time have arrived, the hot-air bath has instructed us in one no less important, and at which our ancestors would have looked aghast. It is, that no danger of taking cold need be apprehended when the body, already bathed in perspiration, is immersed in the coldest water.

XII.

INFLUENZA.

THE disorder we have at present to deal with in many respects resembles a common cold, and under this head something has been said about influenza. A description of the local affections there given, is to a great extent applicable to influenza, and need not be repeated here. Indeed, a great mistake is often made in confounding the two affections. Perhaps it is that the prettiness of the name misleads; but this is certain, that true influenza is a much more serious malady than is generally supposed. The disease is an epidemic, and, fortunately, its visitations are not very frequent.

In the days when philosophers believed that things on earth were governed by the heavens, the present malady was attributed to the influence of the stars, and the Italians gave it the name of "Influenza"—pre-eminently the influence—and this term has been adopted into English. The *grippe,* or the *seizure,* the name by which it is known to the French, is more descriptive.

The primary symptoms of influenza are much the same as those of ordinary catarrh. The patient has a sense of tension in the forehead; his eyes become watery; and he sneezes. Discharge from the nose, cough, and oppression at the chest, soon ensue. But the chief characteristics of influenza are a dull pain in the forehead, which is very oppressive, and an extraordinary prostration of strength, with mental depression, listlessness, indisposition for the least exertion, and utter want of appetite. The skin is generally moist, and the perspirations which occur are not critical, as they seem to be in certain cases of fever. As the disease advances, the discharge from the nose irritates the upper lip, so as to make it red and tumid; the sense of taste is in general impaired. The disease usually lasts four or five days, and, when it subsides, the patient not unfrequently finds himself as much weakened as if he had gone through a long fever. Weeks often elapse before he has regained his original tone and vigour.

Such is a sketch of influenza, as it generally shows itself; but it varies a good deal in different epidemics. Sometimes the symptoms do not exceed those of a common cold; at other times, in addition to severe headache, there are piercing pleuritic pains of the side, associated with inflammation of the lungs. Fever runs high, and there is nightly delirium. Under such circumstances, many patients are carried off. It is remarkable that the very young and the very old are less liable to the disease than the strong and the middle-aged; but when the disease seizes the aged, or those debilitated by other diseases, they often die from its effects.

Influenza is a disease of depression, and requires supporting treatment. Centuries before it was discovered that the lancet could be almost altogether dispensed with, it was found that bleeding was deadly in this disease. "Where blood was let," says an old author, "the disease proved malignant and pestilential, being attended with a violent, cruel, and unheard-of malignity, and made bad work." We are told by the same author, speaking of the epidemic of 1557, that in the small town of Mantua Carpentaria, three miles from Madrid, where the disorder raged with uncommon severity, "two thousand were let blood of, and all died." In this account we have had a sad exemplification, not only of the danger of routine practice, but of the difficulty experienced in throwing off old traditions. Given a tradition that every kind of feverish excitement can be only treated successfully by withdrawing a portion of the vital fluid from the body, and the responsibility of breaking down the tradition becomes enormous. No one will dare not to bleed, lest the patient should suffer from the omission, and no chance is left for ascertaining that what is intended to cure in reality kills. We live in days enlightened by the mishaps and the experience of the past, and from these we have learned that to husband and improve the quality of the vital fluid is the most successful treatment in all diseases accompanied by debility. Good beef-tea, then, with a fair allowance of generous wine, quinine, and other tonics, are the best remedies for influenza. Complications, such as inflammation of some important organ, require of course special treatment.

Unlike epidemic cholera, which seems to be of comparatively modern origin, influenza possesses a long lineage, and pierces the depths of antiquity. Hippocrates, the father of medicine, mentions the disease. In the "Annals of the Four Masters," an Irish manuscript of the fifteenth century, it is stated to have been epidemic in Ireland in the previous century. It was very fatal in France in 1311; and in 1403, the law-courts in Paris were closed on account of the deaths which it caused.

In the sixteenth century, epidemics were very prevalent in England. Sweating sickness and influenza at various times devastated the land. There can be no doubt, that to the habits of our ancestors, and the little regard paid to sanitary matters, the great mortality was mainly due. There is a curious letter extant, written by Erasmus to the physician of Cardinal Wolsey, in which this matter is touched with the hand of far-seeing genius. Erasmus says that he is grieved, and wonders how it happens, that Britain has for so many years been afflicted with continual plagues. He complains that the English have no regard to the aspect of their windows or doors, and that their rooms are so constructed as to be incapable of being ventilated. The streets, he adds, are covered with clay and rushes, which are so seldom removed that the covering sometimes remains for twenty years, and that beneath this covering is a layer of filth not fit to be mentioned; a most unwholesome vapour is exhaled from this. He adds, that it is his firm opinion that the island would become much more wholesome if the chambers were built so as to be exposed to the air on two or three sides, the glass windows being made to open. It would contribute also to health, he says, if more sparing diet was used and less salt provisions were consumed.

Happily we can make a cheering comment on this remarkable letter. Drainage, ventilation, and the food of the people have, since the time of Erasmus, been immensely improved, although finality in these matters has not by any means been reached. The results have, however, been most gratifying, as the bills of mortality prove. Certain epidemics, in obedience to some unknown laws, at uncertain intervals still sweep over the land, despoiled of much of their power. But the plague has been long unknown amongst us; typhus is almost confined to those who are destitute of the ordinary comforts and conveniences of life; and, owing to the treatment having been at length better understood, joined with a better comprehension of the laws of life, influenza is now only exceptionally fatal. If, then, we have lately expended upon the drainage of London alone, the bewildering sum of seven millions sterling,—bewildering if any attempt is made to grasp the details of the huge outlay,—let it be some consolation to the householder, who is in consequence saddled with a tax that will more than outlast his own life, that he is paying for increased longevity. The length of life in England slowly but steadily increases. The incontrovertible reports of the Registrar-General prove this.

We are as much in the dark as to the real cause of epidemics as Hippocrates confesses himself to have been more than 2,000 years ago. Failing to account for them by any known physical agency, he attributes them, with a feeling of religion which does him honour, to Divine interposition. The great Sydenham also confesses his ignorance on this subject, but thought that they may be due to "some occult and inexplicable changes wrought in the bowels of the earth itself, by which the atmosphere became contaminated with certain effluvia which predispose the bodies of men to some form of disease." That influenza does not depend on weather is very plain. It has broken out at all seasons of the year and when the temperature has been at both extremes, and it has advanced in a particular direction in the teeth of prevailing winds. Electricity, which, like the Gulf Stream, is called upon to account for many things with which it has nothing whatever to do, has been supposed by many writers to be the exciting cause of this disease. One thing which favours the idea of some such cause as electricity is the suddenness with which the disease attacks at the same time a large number of people. Several instances of this will be afterwards related. This suddenness of attack is sufficient to prove that influenza, even if it be infectious, which is doubtful, is not propagated essentially by infection. It is ascertained that a person who has suffered from influenza, derives therefrom no immunity from being attacked in a succeeding epidemic of the disease.

Influenza generally attacks a large proportion of the inhabitants of a country which it visits. Women are less liable to it than men, probably on account of their being less exposed to the weather. The ages between ten and sixty supply most cases. The low parts of towns are more seriously affected than the higher and better drained parts. There can be no doubt but that it is caused by a specific poison, which either emanates from the earth or pervades the atmosphere. One proof that it is due to some general cause consist in this,—that it has been often observed that the lower animals have suffered from an illness more or less resembling it during the prevalence of influenza. Various strange natural phenomena have also been associated with it, but it is probable that in many of the cases these associations were merely coincidences. We shall afterwards mention some occurrences of the kind. Whatever may be the exact nature of the cause which produces the disease, it is certain that it progresses in definite directions. The East seems to be the home of epidemics. It is from that quarter that cholera travels, until it reaches the western countries. Influenza pursues a like course, and the ocean, as we shall see, presents no barriers to it. After having pervaded Europe, it usually passes over to America, beginning at the parts nearest to the Old World from which it started.

We possess details of many well-marked visitations of influenza. Some of the most remarkable were those of 1580, 1732, 1782, 1803, and 1836.

The epidemic of 1580 was very severe. Great numbers were destroyed by it all over Europe. In England it was preceded by earthquakes, and a comet also appeared. Other prodigies are mentioned in connection with it. A prodigious number of insects, supposed to rise out of the earth, filled the air; but, most strange of all, "in Kent and the marshes of Essex was a sore plague of strange mice suddenly covering the earth, and gnawing the grass roots. . . . No wit nor art of man could destroy these mice, till another flight of owls came and killed them all. A great earthquake in Peru." Such is the curious mixture of truth with exaggeration which our annals contain.

The epidemic of 1732 made its appearance about the middle of November in northern Germany, and before the end of February, 1733, had reached Naples and Spain, having in the meantime overrun all Europe. In the middle of the following October it arrived in New England, and thence turned southwards to Barbadoes, Jamaica, Mexico, and Peru.

The epidemic of 1782 was traced from India, where it seems to have prevailed in October, 1781, to have reached Moscow in December of the same year, and St. Petersburg in the following January. It was in Denmark in the latter end of April, and arrived in London by the second week of May. This epidemic arrested great attention, both on account of its severity and its almost universal diffusion. A great many persons died from it.

The following incident, which occurred at this time, shows that the poison of influenza probably advances like a wave, and thus at once involves whole communities.

The occurrence also proves that, as already said, infection is insufficient to account for its propagation. Captain Kelly, of the *Fly* sloop of war, weighed anchor about ten in the morning, with a crew of 145 men; but before six the same evening, forty were laid up with influenza, and he was obliged to return to Yarmouth Roads the next morning through want of hands to navigate the ship. Several of the men fell at the wheel and were carried below, and not a single man on board escaped attack.

Another marine incident in this epidemic is to the same effect. On May 2, Admiral Kempenfelt sailed with a squadron from Spithead. On the 29th of that month the crew of one of his vessels was attacked with influenza, and the others suffered in succession to such a degree, that the whole squadron was obliged to return to port early in June. They had, in the meantime, cruised only between the coasts of England and France, and no communication with any land had been held. About the same time another large squadron, in perfect health, sailed from Holland under Lord Howe's command. The disease broke out in this fleet just at the same time as it did in the one previously mentioned, although in the last case also no intercourse had been held with land.

It is related by Kirkby and Spence, in their "Entomology," that the brown-tail moth that year occasioned such devastations in the neighbourhood of London, that rewards were offered for collecting the caterpillars, and that it was the duty of overseers of parishes to see them burnt by bushels.

In 1803, the British Islands were again invaded by a very severe epidemic of influenza. It came to us from the Continent, as on previous occasions. It commenced in London, and in about three months was generally diffused over England. Horses, cows, dogs, and even cats, were attacked with an analogous disorder, and many were carried off. On April 26, a remarkable meteoric shower occurred at L'Aigle in Normandy. The stones were counted by thousands, and the largest weighed 17½ lbs. The sheep-farms of Tweedale were devastated by caterpillars, which devoured the grass. Red rain and snow were observed to have fallen in many parts of the south of Europe. The reddish dust which caused this appearance contained eighteen species of animalcules. Dr. Darwin states that "the sun was many weeks obscured by a dry fog, and appeared red as through a common mist." He adds that "the material which thus rendered the air muddy, probably caused the epidemic catarrh which prevailed in that year."

The last well-marked epidemic of influenza broke out in this country in 1836, and lasted about four months. The disease occurred in a severe form, and it was calculated that three thousand persons died of it in Dublin besides those who, although they got over the immediate attack, sank under diseases induced by the epidemic. It was coincident with cholera, into which it passed in many instances; for during this year that much-dreaded disease returned, after a short interval, to our shores. An epidemic also prevailed amongst cattle and sheep.

Much more might be written of the history and nature of influenza, but enough has been said to show that a disease, in the name of which there is something mild and euphonious, is in reality a fierce and too often a dangerous visitor.

XIII.

HEADACHE.

IT is a rare thing to find any one who does not occasionally suffer from headache. In its minor forms it is a very common disorder. But headache is not always in any sense a trifling ailment. Too often it is a very severe one, and occasionally portends serious mischief.

The nature of pain is discussed elsewhere in this work. At present we have to deal with pain localized in the head. And since this pain exists in close proximity with the brain, the centre organ of the nervous system by which the mind works, we learn why it is that headache, in relation to its severity, causes more constitutional disturbance than other kinds of pain, and also why it is so frequently accompanied by mental dulness and confusion.

There are good reasons for believing that the pain is seldom, if ever, seated in the brain itself, while it is clear that in many cases it is external to it.

This strangely-formed, white, pulpy, mysterious mass, possesses no common sensibility. If exposed by the destruction of a portion of the skull, as has sometimes occurred in the human subject, it may be touched with impunity. If it be strongly pressed upon, the result is not pain, but total unconsciousness so long as the pressure is continued. Inflammation of the membranes by which the brain is protected—and it is enveloped in no less than three of these, one within the other—is, however, attended by severe pain. We must look for the seat of ordinary headache in the nerves which have their origin in the brain, and which radiate in all directions about the head.

Headache is, perhaps, always symptomatic; that is, dependent upon and indicative of some other affection. But as it is often the most marked and distressing symptom present, it happens that it is often looked upon and treated as the main disorder.

Headaches are due to various causes, and for the present purpose the best classification will be one founded on this circumstance. It will suffice to describe only those kinds most commonly met with, and which will prove with so many readers to be old acquaintances. These are—

Headache from indigestion, popularly called *sick headache*.

Nervous headache.

Headache from fulness of blood in the head.

Rheumatic headache.

The well-known sick headache is not confined to any particular sex or constitution, but belongs especially to the early years of adult and to middle life. Some persons are much more subject to it than others, while a few seem to be entirely exempt from the disorder. It is, however, the penalty which a large proportion have to pay for any unusual indulgence of appetite. This headache is often preceded by a sense of chilliness: while the feet are cold, and face and forehead are flushed and hot. A dull heavy pain, with a sensation of weight and fulness, is experienced in the fore part of the head. The temporal arteries throb with violence, and this throbbing is felt in the pain. Sometimes the pain moves into one temple, or into the eyeball of one eye. The patient is generally very irritable, and light and noise increase his suffering. He seeks darkness and silence, content to suffer in solitude. There is total want of appetite—nothing but perhaps a cup of tea is taken throughout the day during which the attack continues. Distressing nausea and a sense of rising in the stomach greatly aggravate his suffering. At length this ends in vomiting, attended by violent straining. The contents of the stomach, which are first discharged, are often found but partially reduced, although they have lain in the organ long beyond the usual period required for complete digestion. Afterwards a viscid and intensely disagreeable fluid is alone ejected; and if the vomiting be further continued, bile is at last brought up. This bile was not, however, present in the stomach until the violent straining had been communicated to the adjoining portion of the intestine into which the bile is discharged from the gall-bladder. At first the act of vomiting greatly increases the headache. The return of blood from the head is impeded by the muscular straining, and already more blood than usual is lodged within the skull. But as soon as the stomach has got rid of its acrid contents, and the vomiting ceases, relief is experienced. Sleep, that best of all restoratives, now comes on, and the patient awakes after some time, still somewhat exhausted, but free from pain.

Such is a description of a common form of suffering. It is called sick headache from its constant association with disordered stomach. What, then, is to blame for its occurrence; and how is it to be averted? In a certain number of instances the answer is easy, and the remedy almost as easily applied, by avoiding those articles of diet which each person has learned from experience are injurious to his stomach. There is hardly any individual who has not discovered that certain articles must be regarded by him in this light, and the older he grows, the more he finds it necessary to add to the list. "A man is either a fool or a physician at forty," was the memorable saying of a Roman emperor, in reference to this very matter. No general rules are applicable, because the proverb, "What's one man's meat is another man's poison," is also true. Still there are particular articles which very generally disagree with persons of weak digestion. Hashes and all rich highly-seasoned made dishes are of this class. Mixing up in the stomach along with a meal already too varied, ices, luscious sweatmeats and creams, as is commonly done, is always injurious. But quantity is no less to be considered than quality. A person may sometimes eat a little of a number of articles with impunity, while a greater quantity of a less number of articles would seriously disagree with his stomach. The man who, for the temporary gratification of eating more than he knows he can easily digest, and knowing too that if he does not so digest, he must suffer long afterwards, is without doubt a fool. A long chapter might be written on the folly of injudicious feasting.

Indigestion is of course not always attended or followed by headache. Many persons suffer terribly in the stomach without any trouble of the kind. It is only in those cases—and they are very numerous—in which the head is a weak point, in other words susceptible, that headache occurs. Now, there are two ways of explaining the mode in which headache is produced by indigestion, and there can be no doubt that both come into operation.

First, there is an intimate and direct connection by means of nerves between the stomach and the head. When, therefore, the nerves distributed over the internal lining of the stomach are irritated because they are involved in the general irritation of this lining, the morbid effect is transmitted to the head, and there makes itself known as headache. One form of the disorder, that in which headache comes on *immediately* after food has been taken, can be attributed to no other source.

Secondly, imperfect digestion tends to make the blood itself impure. Let it be remembered that the sole purpose of digestion is to supply the vital fluid with fresh material for the support of the body. But if the blood be tainted by the absorption of ill-prepared nutriment, the brain, which is of all our organs the most easily affected by the circulation through it of impure blood, will suffer. In this way pain is developed, if not in the brain itself, in the nerves which it sends off, and which are so abundantly distributed in its immediate neighbourhood.

There is perhaps no more certain cause of headache than taking stimulants in excess, especially if different kinds be indulged in. The well-known headache on the morning following the indiscretion is unquestionably due to impurities which the excreting organs have as yet been unable to separate from the blood.

It may be here remarked that the circulation in the brain of impure blood, from its having been supplied with ill-prepared chyle, in other words, with a solution of badly digested food, offers an easy explanation of other facts. It shows how the mind itself becomes dulled by indigestion—how the memory becomes impaired and the thoughts confused. It explains the groundless apprehensions and suspicions which haunt the morbid imagination of the hypochondriac. This also indicates how in most cases dizziness, dark images before the eyes, and numerous other head affections are produced.

There is a form of headache which seems to depend on indigestion, since it is attended by the same kind of stomach derangement as that described, in which the connection between cause and effect is not always easy to trace. Like the other, too, it is often called *bilious headache,* because bile makes its appearance, as already explained, in the vomited matters. People otherwise quite healthy are not unfrequently the subjects of it. It is sometimes strangely periodic in its attacks. A person will tell you, "I cannot keep such and such an engagement, because I shall have my headache on that day," yet the interval between the attacks may vary from one to several weeks. This may happen too when great care is taken in diet as well as in other respects. Yet indications are seldom wanting that the natural functions of digestion are previously disordered. This headache is usually preceded by constipation of the bowels, and a timely purgative will in many instances for the present ward off an attack. It seems, in fact, as if the unaided bodily machine was unable to keep going without derangement beyond a limited time. In most instances it is a very refractory disorder, and many of those who have been subject to it for a long period resign themselves to their fate; they simply seek for some alleviation by remaining in bed in a darkened room on the day during which generally the attack lasts.

Nervous headache is the kind to which persons of the nervous temperament are particularly subject. The outward characteristics of this temperament are not difficult to define. The form may be rounded, but is not muscular, the features are refined and impressionable, the spirits easily elevated and as easily depressed. There is great susceptibility both of body and mind, and yet both may be surprisingly equal to a great emergency. Hence it is that the softer sex is especially liable to nervous headaches, and the peculiar functions of the female organization increase this tendency throughout a great part of life. The consequence of all this is, that women suffer from headache much more frequently than men.

Like sick headache, nervous headache varies in severity. At times the whole mass of the brain seems invaded by throbbing pain, while at others the pain is much less acute and quite local. It more frequently attacks the upper and back parts of the head than sick headache. A great many physical causes will induce it, and few are more likely to do so than bad ventilation. It is this which makes going to a theatre with many persons equivalent to going to get a headache. The contamination of the atmosphere caused by its having been breathed and rebreathed by a large number of people, is partly the cause, and in addition the great number of gaslights unduly consumes the oxygen of the air, while the products of the gaseous combustion are poisonous. This is so sensibly felt by many persons that headache is sure to come on if they remain even for a short time in any gas-lighted room.

Particular states of the atmosphere at large are also very productive of headache. Many are affected when it is damp and foggy, others when it is dry and searching. The east wind is in this way an enemy to some. The climate of certain localities makes a great difference. We have known instances in which the comparatively bracing air of Brighton could not be endured on account of headache. The more relaxing atmosphere of South Devonshire is equally injurious to others. The electrical state of the air has also a powerful effect. Some persons get headache at the approach of a thunderstorm, which, although they may be in bed at the time, they can foretell by this means alone.

The foregoing may be regarded as causes which in various ways disturb without exhausting the nervous power; but there is another set of potent causes which exhaust as well as disturb it—excitement, even of a pleasurable kind, in very susceptible persons; depression caused by grief, anxiety, or disappointment, night-watching, over-fatigue, long-fasting, and cold feet, are all well-known causes of headache.

As may be supposed, the causes which produce sick or bilious headache may be combined with those of nervous headache. The complication in such cases renders the disorder more intractable.

Hysteria is the cause of a singular form of headache. Spasmodic pain is first experienced in the abdomen, from which it extends to the throat and head. Sometimes the headache occupies a mere spot in some part of the head, and the pain is then very intense. It was from these circumstances that it was termed *clavus*, or the nail, by the old writers. By this is intended to be expressed that the pain is like that which might be caused by a nail driven into the head. The suddenness of the attack is in these cases remarkable, and it subsides, usually after eructation of gas from the stomach, with equal abruptness.

Allied to nervous headache is that caused by residence in a malarious country. It is, in fact, one of the phenomena of ague, but the true ague fit may be entirely wanting. This headache is generally periodic, and attacks one side only of the head. Megrims is the popular name for a kind of headache to which women are more especially liable, and which, although intermittent, and often observing regular intervals, is caused by some kind of nervous exhaustion such as has been already described.

Headache from fulness of blood in the head affects those especially who are of the sanguine temperament and plethoric habit. Such persons are of stout build, they have red faces and short necks, and although commonly regarded as "pictures of health," too often present a deceptive appearance.

Nature has taken great pains to prevent congestion, that is, an undue accumulation of blood within the skull. But on this subject it would be out of place here to enter into details. It will suffice to say that the proper action of the brain depends on a properly regulated supply of blood. Now, a disturbance of the balance occurs from two causes—either there is too much blood in the entire system, as sometimes happens in plethoric individuals, or else there is relatively too much blood in the head. Both conditions may give rise to headache, but the last is that which is far more common, and therefore concerns us most.

Many causes induce a determination of blood to the head in those predisposed to it. Violent passions and emotions of the mind, intemperance, heated rooms, long continuance of the stooping posture, etc., are amongst the number. But no cause is more productive of it than direct over-stimulation of the brain. Every literary man knows that if he works beyond a certain point, his head becomes hot and throbbing, his thoughts dull and confused, and if he still persist in his labours, headache is sure to follow. Now these results, it will be found, do not depend so much on the time during which the attention is occupied in a given direction, as upon the amount of work imposed upon the brain. Four hours' continuous reading will not have the same effect as if the same time had been devoted to original composition. Blood is the proper stimulus of the brain; and when it is in an active state, and thoughts are being elaborated, it contains more blood than when in the comparatively passive condition of comprehending the thoughts evolved by the brains of others. The immediate cause of sleep, which, when sound, implies total inaction of the brain, is that the brain becomes comparatively bloodless; when, on the other hand, the brain is most active, it contains most blood. Here, then, is a matter for the serious consideration of all who live by their brains. The delicate organ gives a timely warning of overwork in the headache which it causes. And if the brain be habitually ill-treated in spite of warnings, there is great danger of the congestion becoming permanent and the headache chronic.

Rheumatic headache differs from the other kinds described, in its cause, its nature, and in the parts affected. It always proceeds from exposure of the head to cold; the pain is dull and heavy, and is always worst at night. It affects both the front and the back of the head, and is apt to shift about. It is seated in the muscles of the head, and affects especially their tendinous structures, and the painful parts are very tender on pressure. But there is neither heat nor throbbing; on the contrary, it is often accompanied by a sensation of cold. This form of headache belongs to the rheumatic constitution, and usually attends those who have suffered from rheumatism in other parts of the body.

As for the more inveterate and fortunately more rare forms of headache, dependent on organic disease of the brain, we do not at present take them into account.

It will be well to say a few words in conclusion, as to the prevention of, and the simpler remedies for, headaches. In every case, however, in which the attack is violent and repeated, skilled advice should be sought. We have already said that headaches are symptomatic, and no time should be lost in ascertaining the real seat of disease.

As for headaches dependent on indigestion, we may once more say, that attention to diet is of the greatest importance. Nothing will compensate for the want of this: but in addition, fresh air and exercise, and the avoidance of everything which interferes with health and therefore with digestion, are indispensable. The same observations apply to the treatment of nervous headaches. Whatever tends to keep the general health at the highest possible point, will, in the same proportion, diminish the headache. Coldness of the feet should always be guarded against. A nervous headache is sometimes removed by keeping the feet for some minutes in water as warm as can possibly be borne. In other cases a good cup of tea is very useful. Tea, however, being a nerve stimulant, the repeated use of which is followed by nervous depression, should not be used too freely, because it tends to perpetuate the very disorder which it is employed to relieve. Twenty drops of sal volatile in a little water are not injurious, and are frequently very efficacious. In cases of headache from immediate exhaustion or fatigue, nutritious food and wine are the best remedies. Some of the headaches caused by too much blood in the brain are those which more particularly concern the medical practitioner. As for such as are due to over mental exertion, the remedy is in every one's own power. Let it be remembered that while the brain tires just as do the arms and legs, over-exercise of the brain, for reasons previously given, is much more injurious than over-exercise of the muscles.

For rheumatic headache the best domestic remedy is warmth, and this the patient instinctively seeks. This, when the pain is severe, may be advantageously supplemented by a mustard poultice applied as near the affected part as the hair will permit.

XIV.

SLEEP.

SLEEP is as necessary to existence as food, and yet sleep is in fact a partial suspension of some of the functions of life itself. All these functions are performed with intermissions. Rest is in some way or other provided in every instance. Respiration and the circulation of the blood never cease for a single minute from birth until they are still in death. Notwithstanding this, the heart reposes during about one-fourth of life, and the lungs are inactive during about one-third of the same time. In the case of the heart, this is effected by an interval of rest which occurs between each combined act of contraction and expansion, and the beginning of a fresh act; and in that of the lungs, by a period of repose between each expiration and the succeeding inspiration. The stomach, the liver, and the various other glands have also their times of rest.

"Blessings on him," says Sancho Panza, "who invented sleep." This is a sentiment in which all the world will agree. Sleep is, indeed, as much the true remedy for the troubles and worries of the mind, as it is for the fatigues of the body. In every one's life there are occasions when the gloom of the present is only exceeded by the darkness of the future. If there were no such thing as sleep, a man would succumb either mentally or bodily; he would die of exhausted nervous power, or if it were possible for him to live, would become a maniac.

After some hours of the deepest mental distress, relief is usually brought by sleep, and the sufferer feels his exhausted powers revive. He wakes with the memory of his troubles still present to his mind, but also feeling that he is better prepared to face them. The keenness by which they wound him is somewhat blunted; and this gradual process of blunting is nightly repeated. Thus, by causing intermission in our troubles, it is that "tired nature's sweet restorer" reanimates our drooping spirit.

The immediate cause of sleep—that is, the mechanism in the body by which it is produced—was until recently quite misunderstood. It was formerly supposed that pressure on the brain afforded the explanation. Most writers on the subject have adopted this view, and some of the facts by which it is supported are very striking. Apoplexy is caused either by unnatural fulness of the vessels in the brain, or by the rupture of a vessel which allows the escape of blood, and in either case pressure on the organ is established by one of them. This affection is attended by drowsiness, or by complete unconsciousness, according to the degree of pressure thus exerted. From this fact it has been inferred that sleep is caused by accumulation of blood in the head; and in support of this view certain other facts have been advanced, such as, that full-blooded people are usually the best sleepers, and that the recumbent position which promotes the flow of blood to the brain, induces sleep.

In accordance with these views, an ingenious theory was proposed to account for sleep. The brain is formed double; that is to say, of two equal portions or hemispheres, each having the same shape, one of which is placed at each side of the skull. Imbedded in each of these hemispheres, there is a cavity called a ventricle, and in each ventricle lies a peculiar agglomeration of flaccid-looking blood-vessels, as seen in the dead body, called the choroid plexus. Now it was supposed that when sleep took place, these vessels became so greatly distended with blood as to fill up and make pressure upon the sides of the cavities, and that this pressure continued so long as sleep continued. Many instances have occurred in which a portion of the brain has been laid bare by accident, or as a curative measure. In a case of this sort it is always found that consciousness can be instantly suppressed by pressure upon the brain. This was supposed to give strong confirmation to the pressure theory of sleep. But there is a wide difference between stupor and sleep; the one is a result of diseased action, and it is difficult or impossible to rouse the person from it, while the other is a natural state, from which he is easily aroused.

It has now been determined, that so far from containing more blood than usual, the brain during sleep contains much less blood. We are told on very high authority, that "the blood is the life" of the body, and the tendency of modern physiology is to regard the blood as the origin of all force, and of all the functions in the system. Now when the circulation in the brain is diminished, it becomes deprived of the proper stimulus by which its state of activity is maintained; its vitality, in fact, becomes lowered, and it sinks into a state of quiescence. It then obtains rest, which during our waking hours it never has for a single instant. And it is doubtless during sleep that the waste the brain has previously undergone is repaired, and that the injuries inflicted upon it by over-exertion are made good. For it must be borne in mind that every act of life, whether it be the motion of the hand which guides the pen in writing this sentence, or the action in the brain, which conceives it, is accompanied by waste.

The proofs that sleep depends on a comparatively bloodless state of the brain, have been chiefly derived from experiments on the lower animals. And here we must at once meet an objection that has been raised on the score of cruelty, and that such proceedings are unjustifiable. First, it must be remembered that the operative portions of all experiments of the kind are conducted while the animals are under the influence of chloroform, by the benign effects of which all pain is annihilated. Secondly, while we regard with abhorrence the unnecessary mutilation of any creature, we are as decidedly of opinion that it is proper and justifiable under certain circumstances. The close analogy in structure which exists between man and the lower animals, has, by means of experiments on the latter, led to a greatly extended knowledge of the human functions. There has been so much lately of what we regard as a mistaken advocacy of the rights of the lower animals in this matter, that we have been tempted to digress thus much in order to state plainly our own convictions before the experiments to be now mentioned are brought before the reader.

Portions of the skull have been removed from living dogs, by experimentalists in this country, in France, and in America. By this means the brain has been laid open to accurate observation. It has been determined that when the dog sleeps the exposed brain collapses, that it sinks within the skull; when, on the other hand, the animal is awake, and especially if excited, the exposed brain swells out, and sometimes even protrudes beyond the aperture in the skull.

These observations are supported by what may be easily verified, but in a less evident degree, in the human subject. There exists in the infant, for a considerable time after birth, at the top of the head, where the angles of the separate portions of which the skull is composed do not meet, a small space as yet unclosed by bone, and only covered by the proper membranes of the brain and the outside skin. When the infant is pleasurably excited, or when it screams from passion or from pain, this part may be observed to swell out, and when asleep it will be seen to sink below the level which it assumes in the tranquil state while he is awake.

From these and other considerations, it is now the most generally received opinion, that sleep is caused by a withdrawal of blood from the brain.

It is certain that sleep, or at least an intermittent cessation of functional activity, is a necessity of life throughout nature. Every one is familiar with the mode in which many plants close their flowers at the approach of night; and some, as the trefoil, sleep with their leaflets folded together. But besides such peculiar instances, there is a great difference between the functions performed by all plants during the day and during the night. As for animals, no doubt the oyster has his doze, and there can be as little doubt that the warm-blooded whale not only sleeps but dreams. There is an analogy between the winter sleep of animals and that of most kinds of plants which also hybernate, as shown by their leafless and deathlike state.

In perfect sleep there is no consciousness. It has been therefore called with truth the image of death. It is a temporary death, as far as concerns all action and motion which lie under the power of the will. But although the brain is at rest, the heart and lungs continue their tasks, because they are presided over by a department of the nervous system which acts independently of the brain. The brain is the seat of consciousness, and from it all the nerves which originate and control voluntary motions take their rise more or less directly.

Dreams generally occur when sleep is unsound, and the phenomena give much support to the theory of Gall, that the brain consists of separate organs. When, says he, "one organ is active, the dream is simple: the object of our love is embraced, harmonious music is heard, we fight our enemies, according as one organ or another is performing its functions." Dreams are supposed by many to be excited chiefly by the memory of something which has occurred a short time previous to falling asleep. But this is the exception rather than the rule. They consist more frequently of the revived recollections of old events, and often of those which seem to have been quite forgotten. One of the most remarkable things connected with dreaming is the absence of judgment. We converse with the dead, and even though we may know them to be dead, this excites no surprise. Fear also is generally absent. Another curious circumstance is that space and time have no existence in dreams. It has happened to most people to dream that they passed through some long period of days or even of years, while they have been only a short time asleep. But still more curious is the fact that some sudden impression on the senses—such as the noise of shutting a door, or the entrance of light into the room where a person is asleep, and by which he is awakened—is often the exciting cause of an elaborate dream, in which the noise or the light is the point upon which all the incidents turn. There seem, indeed, to be many things connected with our mental structure which are, as it were, analysed and dissected for us by the process of dreaming, could we but interpret them rightly.

A book might be filled with the account of the so-called prophetic dreams which have been published. Many otherwise strong-minded persons have been so struck by a dream of this kind as to give credence to the connection between it and the event which it appeared to foreshadow. But it has always seemed to us that in such cases one consideration has been entirely overlooked; it is this: People are constantly experiencing remarkable coincidences, such as the unexpected meeting with persons of whom they had been at the time talking or thinking; or the coincidence may be of such a nature as to make it important or valuable in connection with something about to be done or not to be done. But it never occurs to them that in such a matter anything supernatural has supervened. Now, since coincidences are by no means rare in the waking world, why should they be regarded as rare in connection with the world of dreams? Why, in other words, should it be thought necessary in the one case to attribute that to the supernatural, which is accepted as in accordance with the doctrine of chances in the other case? Let it only be considered what thousands of dreams are nightly experienced, and that out of these thousands a considerable number have sufficient point to be remembered afterwards. Is it, then, surprising, considering what occurs in every-day life, if in a few instances our dreams seem to be fulfilled? This without question is the true explanation of so-called prophetic dreams.

Dreaming is not peculiar to man. Horses neigh in their sleep, and every one is familiar with the angry growls, as well as the cheerful bark, which proceed from the sleeping dog. There can be no doubt that the memory of incidents in dog-life, such as of the combat or of the chase, are in such cases present to the animal's consciousness. Children dream almost from birth, and they suffer more from frightful dreams than adults do. The dreams of childhood not unfrequently make impressions upon the mind which endure throughout life. It has been supposed that our dreams become less extravagant and inconsistent as we grow older. This seems true on the whole; but at times the most extraordinary dreams occur at every period of life. Old people seem to dream more than the middle-aged; but, unlike the young, the aged seldom speak in their sleep.

Nothing has a greater influence in producing dreams than indigestion. A late meat supper, taken when the want of it is not felt, is almost sure to disturb rest and cause uneasy dreams. It is recorded of the authoress of the "Mysteries of Udolpho," that she was in the habit of supping on the most indigestible things possible, for the purpose of conjuring up horrors, to be afterwards transferred to her pages. Dryden on the other hand, is said to have eaten raw flesh with the view of obtaining splendid visions. As already stated, external circumstances have much power in modifying or inducing dreams. Instances are recorded in which any kind of dream could be procured in the sleepers by whispering in their ears. An officer, who was the subject of practical jokes of this kind, has thus been made to go through the different stages of a duel, and at last to fire a pistol when placed in his hand, by the report of which he was wakened. On another occasion the same person was in this way led to believe that he had fallen into the sea, when he immediately moved his limbs as if to save himself by swimming. He was then exhorted to dive, in order to escape from a shark, and in attempting to do so received a severe injury by throwing himself from the bench on which he lay. At another time, when living in camp, he was made to believe that he was engaged with the enemy, and that the man nearest to him had fallen. Upon this our sleeper exhibited such marks of fear that he rushed from his bed, and was only roused by falling over the tent ropes. This gentleman, probably from motives of convenience, was in the habit of stating that he never preserved any distinct recollections of his dreams.

Many people answer questions put to them during sleep, and some awkward disclosures are said to have been in this way obtained.

Not only was it an ancient belief, but some amongst the moderns, such as Baxter, supposed that dreams were caused by the suggestions of demons or spirits which haunt our atmosphere. They imagined that these incorporeal beings possessed the power of thus tormenting, of amusing, or even forewarning us in our sleep, according as their intentions towards us were bad or benevolent. But there is no necessity for any such supposition. We know that in the waking state thoughts spring up in the mind without any suggestion from our senses, and apparently in a spontaneous manner. When, therefore, the brain becomes excited in sleep, by the aid of memory, images are formed which, since judgment remains in abeyance, take form and action. We have seen, too, that in some cases dreams may be produced by exciting bodily sensations, and, in fact, a large class belong to this order. There is a great tendency to exaggeration in dreaming. If the bedclothes fall off and the sleeper becomes chilled, he is apt to dream that he is in some way subjected to the influence of extreme cold. If, on the contrary, he is oppressed by too much covering, he may dream he is sweltering under the rays of a tropical sun. The smoke of a chimney filling the room may suggest the conflagration of a city; the sound of a flute, an harmonious concert; while that of a trumpet may excite a vivid representation of the last day, the dead rising from their graves, and marshalled by angels preparatory to that most awful of all scenes, the Final Judgment.

It is not, then, to be wondered at if the intellectual faculties sometimes continue active during sleep, and that the results have been found equal to the mental power of the dreamer. La Fontaine made admirable verses in his sleep. Alexander is said to have planned battles. In the same way mathematicians have solved problems, and schoolboys have accomplished tasks. This leads to the consideration of sleep-walking, or somnambulism. For in some instances, not only have mental feats been performed during sleep, as the composition of poetry or the solution of a problem, afterwards preserved by the waking memory, but the sleeper has risen from his bed and deliberately written down his poem or his problem. In this condition not only are the memory and intellectual powers in an active state, but the powers of volition are also more or less active. In addition to this, one or more of the senses is aroused, while the others remain dormant. If the sense of sight be alone thus stimulated, the dreamer may see objects perfectly, and yet be completely insensible to sound; or he may see and hear, and be quite insensible to touch. In the meantime, power, as regards the exercise of his muscles, may be complete. Thus he may write down his thoughts, or he may do his mechanical work, and then return to bed and to complete unconsciousness. But as in such cases judgment is also in abeyance, his actions may be not only erratic, but fraught with danger to himself or to others. He walks safely on the edge of a precipice, or on the roofs of houses, only because he has no fear. He sometimes avoids danger, and this has been attributed to a kind of instinct rather than to reason. But to us the influence of habit seems enough to account for all. He will not willingly place his foot where there is absolutely no foothold, because he has always been accustomed to this precaution.

Very numerous authentic instances of this affection are recorded; and it may be well here to draw attention to the difference between the kind of testimony by which such facts have been established and that upon which the occurrence of supernatural dreams rests. The evidence in case of sleep-walking is objective—the fact is obvious to others, and is generally established by many witnesses; but in the case of supernatural dreams, or of apparitions, the evidence is generally altogether subjective, and dependent upon the statement of the individual who is the subject of the phenomena. It has been already pointed out that coincidence must be taken largely into account, in any attempt to explain so-called prophetic dreams. But in case of what may be called the higher manifestations, in which some extraordinary revelation is said to have been verified, or some startling vision has been seen, it is a suspicious circumstance that the accounts are seldom those which come direct from the person who has experienced them. Men easily magnify what they fear, and such narratives never lose by oral transmission.

But to return to sleep-walking. In 1686, a brother of Lord Culpepper's was tried at the Old Bailey for shooting one of the Guards. He pleaded somnambulism, and nearly fifty witnesses were called to prove the extraordinary things he did in his sleep. Upon this evidence he was acquitted. A lad at Fribourg, who had been a somnambulist from his infancy, was in the habit of reading in his sleep; he would also, at the request of his tutor, find out places on the maps, which he did more readily than when awake. His eyes were at such times always open and fixed. In America, there was the case of a farmer who would rise in his sleep and thresh out several bushels of corn in the dark, and also carefully separate the grain from the straw. A drover was known in the same way to have killed and quartered a sheep. Dr. Haycock, of Oxford, delivered sermons in his sleep; nor could he be prevented even by rough usage. Such a list might easily be increased; but a few instances are given to show what has been accomplished by sleep-walkers.

As might be expected, it is unsafe to try to waken a somnambulist when discovered in a position of danger —such as on a window-ledge or on the roof of a house. If, as would most probably occur, he did not fall when in the act of wakening up, he would still run the greatest risk from an unsteadiness which he had not experienced while asleep. Cases are also recorded in which the mere act of rousing the person has been attended by fatal effects. It is not surprising that a person even of strong neves should be violently agitated by finding 'mself in a position at the moment altogether inexplicable. In a case of weak nerves, a shock might be terrific. An instance is related of a lady who was so persistent a sleep-walker, that her friends were in the habit of securing the windows and door of her chamber, to prevent her escape during the night. On one occasion these precautions were neglected, and she was discovered in the adjoining garden. She was there awakened by her friends, but such was the shock which her nervous system received, that she expired almost instantly.

The affection called nightmare is in certain respects distinct from ordinary dreaming. While the imagination and the memory possess full fling, the power of the will is either absent or greatly impaired. In addition to this, the function of respiration is much impeded; and out of this, in some shape or other, a horrible association of ideas usually springs. Nightmare, in fact, furnishes some of the most distressing sensations that can be experienced. All the store of horrors which the mind has accumulated or conceived seem to come up at its call. From these, whatever is most disgusting or appalling seems to be selected, and to be moulded into shape. The sufferer is tortured by demons; he is gored by bulls; entwined by serpents; sat upon by some slimy monster; or drawn by a fiend to the very edge of a precipice, on which he hangs only by every effort of his strength. There is often a feeling that such suffering is inflicted through malice, and that some malign influence is at work against him, to which all resistance is vain. A sense of oppression and want of free action are indeed characteristics of the affection. If the person thinks he ought to run, he finds that he can hardly move his legs. If he tries to escape through some door or aperture, he finds it too narrow. He fancies himself buried alive, and is unable to turn in his coffin or to make any noise that would bring help. If he struggles with some monster, it is only to exhaust himself to no purpose; his toil is only rewarded by the mocking laugh or the demoniacal stare of his tormentor.

Such is an imperfect attempt to describe the sensations caused by nightmare; but most readers will be able to complete the picture for themselves, in a manner more forcible than can be expressed in words. Sometimes we pass from a state of perfect sleep into that of nightmare; at other times it comes on when we are between sleeping and waking, or when just dropping off to sleep. Generally speaking, the sufferer is roused by the violence of the attack, and it seems to be thrown off by a great effort of voluntary motion. He is then apt to rise up in bed, and sometimes cries aloud for help. As soon, however, as the capacity for action is brought under the power of the will, the attack is at an end. The heart now beats violently, and a cold shivering sometimes comes on.

Nightmare generally happens to us when lying on the back, but this is not invariable; and it is often difficult to say whether or not the person has not turned on his back during the struggle which precedes recovery. What we have said of delusions about the lapse of time in reference to dreaming, applies also to nightmare. It is, therefore, impossible to determine how long an attack may have lasted. A minute of such misery may well appear an hour.

Indigestion is unquestionably the chief cause of nightmare. Any one whose digestion is not the strongest, may almost infallibly bring it on by taking without appetite a late heavy supper. An excellent receipt for it would be a veal pie, in which solid indigestible meat is combined with pastry. The disorder also plagues people who are asthmatic.

Various explanations have been offered of the immediate cause of nightmare; but impeded respiration is at all events essentially concerned. This may be induced by flatulence, which causes the distended stomach to press against the diaphragm, and so interferes with the free motion of the lungs. But an undigested meal lying in the stomach may in another way cause disturbance in the chest. The stomach irritation is then transmitted to the lungs by means of their intimate nervous connection. The cure of nightmare, unconnected with organic disease, consists in avoiding suppers, attention to diet in general, as well as in a sufficiency of fresh air and healthful exercise.

The approach of sleep is known by a sense of weariness and muscular fatigue. Attention to what is passing before the senses flags, and conversation fails to excite it. All external impressions grow dull, the memory becomes confused, and questions are replied to incoherently. If we struggle against the invader and try to read, the lines seem to run into one another. The head droops at intervals from momentary unconsciousness, the upper eyelids close in spite of every effort to prevent them. If sleep is now encouraged, a brief and not unpleasant state of semi-consciousness steals on, which soon passes into complete oblivion.

Waking probably depends on the return of blood to the brain in obedience to the stimulus given by one or more of the senses, as light, noise, or touch. Habit, too, has a strong effect; and there is no doubt that all these influences are controlled and directed by the sympathetic nervous system, by whose ever-watchful agency the functions of life are kept in action both during sleep and when awake.

The proper duration of sleep cannot be absolutely fixed; some men require much more than others; and age, the amount of work performed during the day, whether physical or intellectual, and other circumstances, regulate the demand. Infants sleep the greater part of their time. Children require more than adults, and, as a rule, the middle-aged more than the old. It is no uncommon thing to see old men pointed out as models of early rising to their younger friends. This is a mistake, for in truth the old get up early because they are unable to rest in bed. But there are exceptions to this. Old Parr slumbered away much of his later life; and De Moivre, when past eighty years of age, slept twenty out of the twenty-four hours. It has also been observed that in the dotage of old age, as if to complete the parallel between the first and second childhood, sleep again predominates. Sleep in the aged is very apt to occur after meals.

As a rule it would seem that the larger the brain of any animal is in proportion to its body, the more sleep it requires. Birds, which have small brains, sleep little; dogs, whose brains are much larger, sleep a great deal. But monkeys sleep little, although their brains are not small.

Perhaps no better division of time can be made than that of Alfred the Great. He assigned eight out of the twenty-four hours to work, eight to amusement, and eight to sleep. The demands of modern life in most instances sadly disturb such a relation between work and play; but the period he assigned for sleep seems to accord with general experience. Less than eight hours' sleep is insufficient for most men and women when in health, and more is unnecessary or even injurious. In this matter, too, there are exceptions. Jeremy Taylor trained himself to exist on three hours' sleep out of the twenty-four. Frederick the Great and John Hunter slept only four or five hours in the same time. Wesley lays down the proper duration of sleep at six hours, and Lord Coke at seven.

Many instances in which sleep has been greatly prolonged beyond the average duration are also on record. Boerhaave mentions the case of a physician who conceived the idea that sleep was the natural state of man, and he slept eighteen hours out of the twenty-four. But he soon slept himself out of the world, as he died of apoplexy induced by his indolence. Elizabeth Perkins fell into a deep sleep, from which nothing could rouse her, and remained in that state between eleven and twelve days. A man who lived near Bath is said to have at one time slept for a month. There is little doubt that in many of these cases the brain was diseased. Narcotics sometimes cause sleep to be much more protracted than was expected. Notwithstanding numerous exceptions, it seems that average people require to spend about one-third of life in sleep.

The hour of going to bed must of course depend on the habits of the individual. Persons who get up early must go to bed early, and *vice versâ.* Much has been written in praise of early rising, and with some truth. There is an undoubted relation between sleep and night, when, with few exceptions, all animated nature reposes. It is also a good, though not an indispensable, rule of health to retire to rest early; the real point being to obtain sooner or later the requisite eight hours' sleep.

No greater domestic improvement has been effected than the substitution of hair mattresses for feather-beds. Perspiration is more active during sleep than when we are awake, and it is unduly encouraged by the sinking of the body in a soft bed, which also enervates the entire system.

The open state of the pores of the skin makes sleeping in the open air hazardous. But the belief that the moonbeams exercise a peculiarly noxious influence on a sleeper who is exposed to them is unfounded. Most people sleep best on the right side; the chief reason of this is that the heart lies towards the left side. When, therefore, a person lies on the right side, greater freedom is given to its motions. In many countries it is the habit to sleep on hard boards, and the ancient Egyptians slept with the head supported on an iron bar bent to its shape. This one thing only seems to belong to all times and to all countries, that when possible people always sleep lying down. But in cases of great fatigue, neither this, nor even a state of rest, is indispensable. People have often slept while riding on horseback. In the retreat of Sir John Moore during the Peninsular War, many of the soldiers were found to be fast asleep while they were marching. It is indeed astonishing how well sleep can be indulged in under difficulties. Men worn out by fatigue and loss of rest at the siege of Sebastopol, slept soundly in the batteries during a bombardment. Coy and fugitive when sought after, sleep unsought is often an irresistible influence.

A high temperature strongly induces sleep. In some warm climates the siesta, or midday sleep, is an established usage. Sleep from heat is preceded by great lassitude and indisposition to exertion of either body or mind. If a person gives way to it, he drops into slumber quite suddenly, but it is not attended by the refreshing effects of ordinary sleep. He is apt to awake feverish and thirsty, and with a dulness and confusion of thought which last for some time.

A moderate degree of cold prevents sleep, while excessive cold has not unfrequently been the cause of apparent sleep ending in death. In some cases the drowsy tendency from cold is so irresistible, that it is indulged in with the full consequences before the mind. Travellers in the Rocky Mountains are sometimes overtaken by storms far from shelter, and exposed to a very low temperature while crossing this bleak and elevated range. In such a situation to sleep is to die. A remarkable instance of this kind is related in Captain Cook's Voyages.

Mr. Banks and Dr. Solander had ascended a mountain in the island of Terra del Fuego. Here they became exposed to an extremely low temperature, and Dr. Solander, knowing the risk of delay, did all in his power to keep the party in motion. "Whoever sits down," said he, "will sleep, and whoever sleeps, will wake no more." Notwithstanding this, the Doctor was himself the first to give way to the temptation, against which he had so forcibly warned his companions. He threw himself down upon the snow with which the ground was covered, and it was with the greatest difficulty that Mr. Banks could keep his friend from sleeping. One of the black servants now began to give way. Others of the party were then sent forward to have a fire lighted at the first convenient place, while Mr. Banks remained behind with Dr. Solander and the servant. Partly by persuasion and partly by force, they were got through the greater part of a swamp difficult to pass, when both declared that they would not proceed. The black man was now told that he would be frozen to death, and he replied that he wished only to be allowed to lie down and die. Dr. Solander said he was willing to go on, but that he must first sleep. As their companions were unable to carry them, they were now permitted to sit down, and both sank almost immediately into a profound sleep. Soon afterwards the news was brought that the fire had been lighted about a quarter of a mile farther on. They were now so fortunate as to awake Dr. Solander. But notwithstanding that he had not slept more than five minutes, his limbs were almost powerless, and his feet had so shrunk that the shoes fell from his feet. He completed the short journey to the fire with great difficulty, and only by the assistance of his party. But their efforts to save the black servant were unsuccessful.

It may strike the reader as strange that such opposite conditions as great heat and great cold should equally be the cause of sleep, while a moderate degree of cold keeps a person awake. As for the last, it seems to act simply as an uneasy sensation would do in preventing sleep. Extreme cold causes the blood to accumulate in the internal organs, including the brain, because it is driven from the surface by contraction of the superficial blood-vessels. The result of this is stupor, and not sleep, which we have called it only for convenience, and because it has been generally regarded as true sleep. The effect of great heat, on the contrary, is to increase the amount of blood circulating in the superficial parts and in the extremities of the body. This causes a lessened flow of blood through the brain, followed by sleep.

Such is a sketch of one of the most remarkable phenomena of our being. Although modern research has divested sleep of much of its mystery, there is still much to be learned; but, judging from what has been already achieved, we may expect with confidence still greater results.

XV.

SLEEPLESSNESS.

In the preceding chapter, we gave an account of the phenomena of sleep, deduced from the labours of many observers.

So far as has been ascertained, a lessened flow of blood through the brain is the cause of that total obliteration of consciousness and of all voluntary motion known to us as perfect sleep. It is necessary to bear this in mind, in order to comprehend what we have now to say about sleeplessness.

When the brain is most in action, it attracts to itself most blood. Every one who has spent many consecutive hours in literary composition, or in abstruse calculation, will be able to recall the sensation of fulness and of throbbing in the head, and, if the work be still persisted in, the headache which such close application sometimes induces. From these considerations it is not difficult to form a theory of the cause of wakefulness, which facts as well as analogy show to be true. Provided that circumstances are favourable, sleep comes on when that power of the brain through which the mind and the senses act requires to be renovated. It is usually requisite that the body be placed in an easy position, and that access of light and of sound be prevented. As we have previously pointed out, the power of the brain to sustain itself in action may be exhausted more rapidly than ordinary by fatigue, by heat, and by other causes. Habit also, by which all the functions of the body are greatly influenced, has much to do with sleep.

The simplest form of wakefulness, then, is that which occurs from a violation of one or more of the conditions appropriate to sleep. Thus a bright light in the room, an unaccustomed noise, or an uncomfortable bed, suffice to keep most persons awake. An excess in the very causes which induce sleep also commonly prevents it. Over-fatigue is usually followed by vigilance, and such is the effect of habit, that some persons are unable to sleep if they remain long out of bed beyond their usual time of retiring to rest; or, on the other hand, if they go to bed unusually early.

When the brain has been once stimulated to activity, it requires some time before the circulation of blood through it regains the balance which is maintained in the waking state. When this balance is regained, most persons easily fall asleep if other circumstances are favourable. Many people indeed possess the faculty of sleeping at will, by merely closing the eyes and otherwise shutting out external impressions. A great many persons, on the other hand, and particularly those of nervous temperament, sleep with difficulty, and some may be said to obtain repose only by stratagem.

Any intellectual effort immediately before retiring to rest is sure to be followed in such persons by a restless night. If, for example, a game of chess has been played, the various moves and positions on the board are long vividly present before the mind. This kind of misfortune is only to be averted by avoiding the causes which induce it. If, on the contrary, the circulation in the brain is habitually kept at an unnatural tension, the difficulty with which it returns to the state necessary for sleep is nightly increased.

Many articles cause wakefulness when taken internally. Of these, tea and coffee are the most familiar. Every one knows that either, but especially tea, when taken too strong, prevents sleep. Opium, belladonna, or Indian hemp, in small doses, produce the same effect. There are good reasons for believing that all these drugs act alike, in at least one respect, namely, by increasing the circulation of blood in the brain. This is attended by increased activity and power of thought. Each of these substances has also a specific action of its own. There is a difference between the stimulation caused by tea and that from coffee. The pleasurable sensations and the reverie caused by opium are peculiar to the drug. Indian hemp or *hashish*, which is its Eastern name, if taken beyond a certain extent produces a succession of mental images and pleasing hallucinations, the nature of which would of itself require a long chapter to describe. It is remarkable, too, that although all these articles may produce wakefulness, this in some cases depends on the dose in which the particular drug is taken. Opium in sufficiently large doses produces sleep, but tea taken in large quantity is not accompanied by this effect.

Nothing banishes sleep more effectually than pain. Patients suffering from neuralgia have been almost sleepless for months. But no amount of pain can altogether do away with sleep, nor will mental depression or fear prevent repose when exhaustion ensues. Wretches are said to have slept while undergoing the punishment of the rack, and culprits usually sleep soundly on the night preceding their execution.

Cold, when not excessive, dispels sleep, because of the discomfort it induces, and probably also on account of the derangement of circulation which it produces. Coldness of the feet is a very common source of wakefulness. A sensation of dry burning heat in the soles of the feet and palms of the hands, to which some people are liable, and which also accompanies certain diseases, is another cause of sleeplessness. Sponging the parts with vinegar and water relieves this affection.

All mental emotions are unfavourable to repose. The merchant who has been fortunate in some daring speculation cannot sleep if he dwells upon his successes after retiring to rest. Another who has met with reverses will be sleepless from sorrow if, as too often happens, his losses intrude upon his thoughts during the night. But it must be admitted that, as a sleep-dispeller, joy is far inferior to grief. The memory of what we achieve or of what we gain is never so persistently active as the memory of what we lose. The recollection of the one soon dims through repetition, while that of the other long preserves its force.

Another great enemy to repose is an over-active imagination. A man whose thoughts run riot, so that with closed eyes he mentally sees pictures pass in rapid succession, like a vast panorama, will never sleep as long as this state of things continues. One great essential for sleep, as we shall afterwards see, is simplicity of mental action.

Indigestion is a very common cause of wakefulness. Anything which acts as an irritant to the stomach is apt to irritate the brain by means of the close union which exists between these organs through the medium of nerves.

On the other hand, that kind of exhaustion which occurs from want of food frequently prevents sleep. When a person accustomed to dine late happens to dine early, and goes to bed without any substantial refreshment, he is very liable to find himself utterly sleepless. It may be that no actual hunger is experienced. It is rather an indefinable sensation of sinking in the region of the stomach which gives no distinct indication of the want of food. This kind of sleeplessness is apt to be very persistent, because the exhaustion increases in proportion to the time during which the person remains awake. In such a condition a sandwich and a glass of wine or pale ale act better and more speedily than an opiate. No sooner has food been taken, than a glow of comfort and a tendency to repose succeed, and the person soon falls into refreshing sleep. It is not difficult to comprehend how this occurs: the brain in its previously vigilant state was too full of blood, by which its unnatural activity was sustained. When food is taken into the stomach the process of digestion is excited, and the superabundant blood is, by this means, diverted from the head to the abdominal organs.

Another cause of sleeplessness, little recognised, is taking stimulating drinks. It is certain that in a great number of instances stimulants do not agree with the system, and that many people would sleep much better if they abstained from them altogether. Those who indulge freely at night are apt to awake very early in the morning and remain long sleepless. This is by no means inconsistent with the fact that a certain dose of brandy and water, or its equivalent, is considered by some persons indispensable to repose. Anything to which the system has become habituated from constant repetition grows into a necessity. In the present case an unnatural want is established, which, if not attended to, is a cause of discomfort and consequent loss of sleep.

The effects of protracted wakefulness sooner or later show themselves in the strongest constitution. The person becomes gloomy, irritable, and peevish. The memory is defective, and the thoughts confused. Perhaps the most terrible punishment which Chinese ingenuity has devised, is prolonged loss of rest. In some instances it leads the way to, and even seems to be the cause of, insanity. Some of the greatest intellects have suffered from privation of sleep:

Newton's mind was impaired by it in his later years; Southey's insanity was preceded by it. The more gifted and cultivated the mind of an individual is, the more liable he will be to wakefulness. The untutored sons of bodily toil have but few vigils, and amongst all the animals sleeplessness without external cause probably belongs to man alone. The lower animals are soon affected by loss of sleep. In Ceylon, wild elephants are kept constantly awake until they become tame; by this means the spirit of the most refractory is soon subdued.

In order to promote sleep in cases where it is wanting, it is of course in the first place necessary to remove every exciting cause of wakefulness. It is generally essential to give up the use of tea and coffee, and, as has been said, it is sometimes necessary to leave off stimulants. The person should take care that he does not go to bed either with cold feet, or with a stomach that has been either long empty or scarcely filled.

Many devices for inducing somnolence have been practised with more or less success; one of these is combing the hair, which has a very soothing effect on some persons. Another is to have the feet gently shampooed. Walking about the bed-room in one's night-dress, so as to get what Dr. Franklin called an air bath, is a good plan, and the cold-water bath just before retiring to rest, by virtue of its stimulating action, is often successful. In more refractory cases the warm bath may be tried—it acts by withdrawing the blood from the brain. On the same principle, the upright position, by favouring the return of blood from the head, is sometimes useful. It is, indeed, no uncommon thing to meet people who sleep with great facility when sitting in a chair or in a carriage, but who sleep with difficulty when lying down in bed.

The best bed to sleep upon is a hair mattress, and the worst of all is that made of feathers. Many people are so susceptible that they are unable to sleep in a strange bed. A pillow filled with hops, the emanations from which are narcotic, has been sometimes used with success to induce sleep.

People as a rule go to sleep most easily when lying on the right side. Proper ventilation of the bed-room is indispensable for sound sleep and for health.

Sufficient out-door exercise should in every instance be taken, and those who are strong enough should carry it to a sense of fatigue. In the Satires of Horace, to swim three times across the Tiber is recommended as a means of procuring deep repose.

In a state of health, when the balance between mind and body is properly maintained, sleep will naturally follow either mental or bodily fatigue. This balance is often sadly disturbed because the besetting evil of our generation is over-stimulation of certain tendencies. Nothing is more important in order to secure sleep, than to diminish the intensity of thought. Under favourable circumstances this can generally be effected by the will. In other instances, however, the more the will is exercised against them, the more attention is given to the truant thoughts. At length the will, borne down by the torrent of ideas, gives way altogether, and protracted sleeplessness results. It is hardly necessary to repeat here that such an active state of brain implies that the circulation through it is active, and that it is the opposite of this condition which prevails in sleep.

One of the most effectual modes of counteracting this state of things is to force upon the attention some monotonous train of thought, and to tire the brain by its constant repetition. Reading a dull book sometimes answers. Repeating short verses over and over, or counting backwards, is often successful. Monotonous sounds act in this way. Boerhaave ordered for a sleepless patient that water should be so arranged as to drop constantly on a metal pan. The murmur of a flowing stream is for the same reason soporific.

The whole chance of success lies in compelling the mind by a strong effort of the will to give up the train of ideas by which it has been occupied, and to take up the less interesting and more simple ideas or perceptions presented to it.

Many years ago a curious plan for procuring sleep by this means was announced as a great discovery by a Mr. Gardner. As this plan made some noise at the time, and was reported to have seldom or never failed, we shall give a full description of it. Testimonials of the efficacy of his method were published by Mr. Gardner from his Royal Highness the late Prince Albert, Sir F. Buxton, Bart., Sir W. Cockburn, Mr. Sheridan Knowles, and other men of eminence. It may be, then, that some readers may owe us a deep debt of gratitude for placing the priceless blessing of sleep within their reach upon such easy terms.

Let us suppose, then, a person to be in a particularly wakeful state, and that he has tossed and tumbled about into the small hours of the morning without any feeling of somnolence. If he should now desire deep repose, the following proceedings must be adopted.

He is to lie on his right side, with his head comfortably placed on the pillow, having the neck straight, so that respiration may be unimpeded. Let him then close his lips slightly, and take a rather full inspiration, breathing through the nostrils as much as possible. This last, however, is not absolutely necessary, and some persons breathe habitually by the mouth. Having taken the full inspiration, the lungs are to be left to their own action, that is, expiration is not to be interfered with. Attention must now be fixed upon the respiration. The person must imagine that he sees the breath passing from his nostrils in a continuous stream, and at the instant that he brings his mind to conceive this apart from all other ideas, consciousness leaves him, and he falls asleep.

Sometimes it happens that the method does not at once succeed. It should then be persevered in. Let the person take in thirty or forty full inspirations, and proceed as before; but he must by no means attempt to count the respiratory acts, for if he does the mere counting will keep him awake. Even though he may not now succeed in procuring very sound sleep, he will at least fall into a state of pleasant repose.

Such is the account, somewhat abridged, of this much vaunted "art of procuring sound and refreshing sleep at will," given by Mr. Binns in his "Anatomy of Sleep." He, it seems, purchased the secret from Mr. Gardner, and hints at his generosity in having made it public *gratis*. It is founded on the principle that monotony, or the influence on the mind of a single idea, as we have already shown, induces slumber. The inventor had for years suffered great agony, with consequent sleeplessness, from an injury to his spine. In this sad condition, opium and other sedatives were found rather to increase than to allay his sufferings. He was a contemplative man, and at length discovered the secret of "subduing sleeplessness and commanding repose by a simple effort of volition."

The plan is at all events safe, and easy of application; and any wakeful reader can test it for himself.

In many severe cases of sleeplessness, opium and other narcotics are of great use, not only by procuring forced repose, but by breaking through the habit of not sleeping, into which the system had fallen. The administration of such potent remedies, however, requires the skill and the supervision of a medical attendant.

XVI.

VENTILATION.

It argues a serious defect in our present system of education, that it should be necessary to explain the reasons why ventilation is essential to health. Such an explanation would be altogether out of place if people in general possessed even an elementary knowledge of the laws of life; in other words, of the conditions upon which health and life itself can be preserved.

Every one knows that fishes cannot live out of water, while land animals, for whose existence air is necessary, speedily perish if immersed in water. But if the explanation of these simple facts be asked, we believe we are not wrong in saying that the majority of persons would be unable to reply. Let it be remembered, then, that both fish and men, when they change places with each other, as regards the element in which they live, die from the same cause. That cause is the want of oxygen, the universal and indispensable agent of animal life. The fish dies in air because its breathing organs, or gills, are only adapted for purifying its blood with the oxygen with which water is saturated. Boil the water, and thus expel from it a great part of its oxygen, and, when cooled down to its ordinary temperature, place the fish in this water, and death speedily follows. A man, on the other hand, dies in water, because his lungs are adapted only for extracting oxygen contained in air.

The atmosphere which surrounds the earth, forming a gaseous envelope of the thickness of about forty miles, has a definite and very uniform composition. Every hundred parts of it consist of 21 volumes of oxygen and 79 volumes of nitrogen; or, if we estimate its composition by weight, of 23 parts of oxygen and 77 of nitrogen. Practically, we may say that a fifth part of the atmosphere consists of oxygen. It also contains about one part in 10,000 of carbonic acid; a gas which, except it be highly diluted, is destructive to animal life.

Oxygen is, as has been said, a necessity of life, and the pure gas will sustain life for a short time; but it is of too stimulating a nature to do this long. Nitrogen, on the other hand, cannot sustain life at all: it would be deadly from its negative qualities, because it cannot, like oxygen, effect indispensable changes in blood. It seems that the use of nitrogen in respiration is merely to dilute the oxygen, so as to render it capable of being respired.

Carbonic acid gas is about one-half heavier than common air, and owing to this circumstance it is possible to pour it as one would a liquid from one vessel into another. From the same cause it forms a layer at the bottom of wells or even in a more open situation, as in the case of the celebrated Grotto del Cano near Naples, where it emanates from the earth. Every now and then we hear of sad accidents occurring to miners and others who place themselves in situations where they inhale this gas. The result is stupor, followed by loss of consciousness, and unless help is speedily given, by death.

This is the subtle enemy we have constantly to deal with in our houses, and against which we should be constantly on our guard. It is given off by animals in considerable quantities in the process of respiration, especially when they are in a state of exertion. A man produces about one-third less carbonic acid when sleeping than when awake.

Some persons are much more susceptible of the effects of carbonic acid than others; but, as a general rule, whenever the proportion which exists naturally in the atmosphere is slightly exceeded, bad results begin to be felt. A sense of oppression, languor, headache, and other nervous symptoms are produced. Nor are the evil effects of rebreathed air merely transient. No cause tends more to excite into action a latent tendency to pulmonary consumption, if it does not really produce the disease, than the air of unventilated bedrooms. Air containing one per cent. of carbonic acid is highly injurious, but even half that quantity cannot be long breathed with impunity. Respiration can be continued only with difficulty in an atmosphere containing five per cent. of the gas, while thirty per cent. speedily destroys life.

Besides carbonic acid, the atmosphere contains in much more minute quantities another still more deadly compound, carbonic oxide. This gas is chiefly produced in our houses from the imperfect combustion of carbon in fuel. Carbonic acid, on the other hand, is given off when the combustion is more complete. Warming by artificial heat is also another great source of this last gas. The method of heating apartments so that the escape of the gases produced by combustion has to be perfectly effected, is a most important study. The combustion of some kinds of fuel is accompanied by the evolution of so much carbonic acid, that if ventilation be very defective, immediately fatal consequences may ensue. Every one has heard of deaths ocurring from burning charcoal in unventilated rooms, tents, or cabins of ships.

Other gases more or less contaminate the atmosphere of houses. Sulphuretted and carburetted hydrogen, etc., emanate from sewers, and are most injurious to health. It seems to be impossible, even with the most perfect system of sewage, altogether to prevent the escape of these gases.

Another reason for the necessity of ventilation is, that respired air is always charged with vapour; we see the vapour out of doors when in cold weather made visible by condensation. About six grains of water are given off by the lungs per minute. This in the form of vapour, mixed with rarefied air from the lungs, ascends, because the combination is lighter than common air. It shows that in all methods of ventilation means should be employed to remove the upper strata of air; for although carbonic acid is heavier than the atmosphere, it also is carried up with the respired air. This happens, not only because the breath is warm, but also because the proportion of oxygen, which is is heavier than nitrogen, is lessened by respiration.

Amongst the innumerable laws which go to make up the perfect code of Nature, there is one which is expressed in the mixture of gases with each other. By the law of the diffusion of gases, carbonic acid, which escapes into the atmosphere, although much heavier, soon becomes so diffused that the open air always preserves sufficient purity for the purposes of respiration. But notwithstanding the great bulk of the atmosphere, it is plain that in the course of ages its relative proportion of carbonic acid would be increased by the perpetual respiration of the animal tubes. Here, however, again a beneficent provision is obvious.

It is the function of the plant to absorb carbonic acid and to give out oxygen. Thus, by means of the enormous mass of vegetation with which the land is clothed, the purity of the atmosphere is sustained.

That water is purified on precisely the same principles as air, a few words will suffice to show. It is not long since the true theory of keeping fish in an aquarium came to be understood. Many will remember that the primitive aquarium consisted simply of a vessel containing water, in which fish were placed. It was then always necessary to change the water very frequently, in order to keep the inmates alive. This was, of course, owing to the consumption by the fish of the oxygen contained in the water, and the production of carbonic acid. The modern aquarium, however, contains not fish only, but growing plants. The plants restore the balance which the fish tend to disturb, and thus such an aquarium never requires to have its water changed. All that becomes necessary is to make up at long intervals for the losses caused by evaporation. Since men as well as fish, then, depend for their existence upon this selfsame oxygen, and the sea, with interminable beds and groves of its peculiar vegetation, may be regarded as an immense aquarium, so may the atmosphere be regarded as a deep ocean consisting of a different medium, at the bottom of which live men and other land animals.

What, then, must be the case with people who, neglecting one of the most essential laws of life, shut themselves up in tightly closed day-rooms, and in bedrooms of the same kind, in which, at least one-third of their lives is spent? They are plainly sapping the foundations of health. They do not die speedily, like fish in a bowl of water unchanged, because they are not equally confined in their rooms, and because, in spite of all their ignorant precautions, some fresh air gains access to them through crevices. But they languish and feel unrefreshed by sleep, they become consumptive and die early, and their offspring is sickly and without vigour. It may be thought that this is an overdrawn picture. Many facts might be adduced to prove that the picture is but too real. Let one suffice. Her Majesty's Foot Guards are men in the prime of life, and undeniably picked out of the general population for soundness of constitution. Notwithstanding this, it was some years ago ascertained that the mortality amongst these men was excessive. It was proved that while the deaths amongst the general male population of the same ages amounted to only 9·2 per thousand, they reached 20·4 per thousand among these vigorous Guardsmen. The investigation to which these sad facts led, showed that the mortality amongst them was caused by consumption, and that this was to be attributed to the very imperfect ventilation of the barracks. For example, a sergeant stated that he could not endure the fœtid atmosphere of the crowded sleeping-rooms before the windows had been opened. No wonder that many of these poor fellows succumbed to noxious gases as surely as, although more slowly than, they would have done to the shot of an enemy. Measures were then taken to ventilate the sleeping apartments, and the mortality among the same troops is stated to be now positively less, instead of being so much greater, than that of the general male population of similar ages.

It would be easy to mention instances of the directly fatal consequences which have resulted from the inhalation of impure air. But having already given a sketch of the composition of the atmosphere, we must hasten to describe some of its properties upon which ventilation depends.

Air in common with other gases expands in volume almost uniformly as its temperature is increased.

1,000 cubic inches of air at 32° Fahr., when raised to 212° Fahr. is increased in bulk to 1,375 cubic inches. This amounts to an increase of three-eighths of the whole volume. Now, one of the laws which regulate the motions of the atmosphere is, that the heavier or less expanded portions of it rush to the lighter or more expanded parts, and this motion continues so long as the difference of density is maintained. Let it be supposed, then, that the hot air, from a fire, as it enters a chimney fifty feet in height is at a known temperature, and that the temperature of the external air is also ascertained, the velocity with which air will move through the shaft is capable of being exactly calculated. The motions of the atmosphere, then, are caused by local alterations in its density arising from changes in its degree of warmth. It is upon this simple principle that the science of ventilation depends. In this way also the lightest breezes, as well as those grand phenomena to which we give the name of tempests, and notably the trade winds, are produced.

The necessity for external ventilation has been foreseen for us by nature. Noxious vapours arising from the earth, the smoke of cities, and the gases produced by decomposition and combustion, are at once dissipated by the winds. How oppressive the atmosphere becomes in calm warm weather, and what a relief it is to feel oneself fanned by a breeze after even a short continnance of such a calm!

We have already said enough to show that when we surround ourselves with an atmosphere confined within a small space, the necessity for ventilation becomes urgent. Pure air is as necessary to us as pure food, and on this subject an old writer says quaintly, "that as everything that is proper for recruiting the decay of the solid or fluid parts of our bodies deserves the name of food, the air ought to be looked upon as real food, and that which is most necessary for us." A future generation will doubtless look back upon us of the present day with pitying wonder. Notwithstanding the knowledge we possess, rooms for living in are constantly being erected in which no ventilation can be effected when the door is closed except through accidental chinks. It comes indeed to this, that such apartments are only inhabitable owing to the imperfection of their construction. Science has, however, not been idle in this matter of ventilation. What is most required at present, is a more widely diffused knowledge of the subject.

A man produces by respiration about ten cubic feet of carbonic acid in twenty-four hours. Suppose him to be confined in a room containing 1,000 cubic feet of air, which a space ten feet square and ten feet high would afford, he would in twenty-four hours contaminate the atmosphere to the extent of one part of carbonic acid in 100 parts of air. A certain amount of carbonic acid given off by the skin would have to be added to this. But suppose twelve persons to occupy the same chamber, and a like effect would be produced in two hours. We have previously shown that such a proportion as that just mentioned cannot be breathed with impunity. Health is daily sacrificed through inattention to the kind of atmosphere inhaled. People spend long winter evenings crowded together in badly ventilated small rooms, or else they pass hours in larger spaces, such as churches, theatres, and other places of assembly, which in relation to the numbers present are equally crowded.

It will be obvious that to insure proper ventilation two things are necessary: first that the cubic space of air in an apartment shall bear a proper relation to the number of persons who inhabit it; and secondly, that the air shall be sufficiently renewed. It is calculated that the cubic space requisite for each person in a house should never be less than 600 feet; but in hospitals, where the air is contaminated with emanations resulting from disease, 1,000 cubic feet in each ward is the minimum that should ever be allotted to each patient. Another great source of the consumption of oxygen is the burning of candles, lamps, and gas-lights. The burning of gas is especially unwholesome, not only on account of its consumption of oxygen being very large, but because of the other deleterious gases besides carbonic acid which are evolved.

In order to do away with the injurious results which must arise from the assembling of persons in artificially lighted rooms, it is necessary that about six cubic feet of fresh air per minute shall be supplied for each person. But this of course involves the condition that an equal quantity of vitiated air be allowed to escape. The art of ventilation consists indeed in effecting this double purpose; and much ingenuity has been expended on the subject.

The different means employed have been divided into two classes—forced ventilation, and ventilation by spontaneous action. The first method is necessary whenever a larger number of persons are congregated in an apartment than its relative amount of cubic space would warrant. Sometimes fresh air, previously heated or otherwise, is pumped in, or it is blown in by a bellows, or a current is set in motion by means of a revolving fan, an Archimedean screw or other contrivance, and in some instances provision is also made for drawing off the foul air by mechanical means. Steam power is often employed to work machinery of this kind. The practical difficulties to be overcome in ventilating by these methods are considerable. No greater proof of this can be adduced than the case of the Houses of Parliament and the different methods of forced ventilation which have been tried for them at an enormous cost.

The scope of this article is, however, limited. What is intended is, to impress upon readers, not only the necessity for ventilation, but how ventilation is to be effected in ordinary houses, by ordinary means.

The commonest and by no means the worst form of ventilating a room is by opening the windows. But since the heated and impure air always ascends, windows should open at the top, and extend to near the ceiling. It is a great mistake, however, to suppose that opening windows upon one side only suffices to ventilate an apartment. It often happens in the still and sultry atmosphere of summer that the temperature inside a room is the same as that outside. In such a case no more change will take place in the air of a room having windows which only open at one side, than would occur in the contents of an open-mouthed bottle immersed in water. In order to change the air of an apartment, means of escape as well as of entrance must be provided. If the door be kept open, so much the better; and if not, the inevitable imperfections in its fitting allow some air to pass. But whatever may be said about the wastefulness or inconvenience of open fireplaces, they have at least one great recommendation. In houses where no provision is made for ventilation—and, as already said, such a provision is altogether exceptional—the chimney is in this respect of essential use. When a fire is burning, an artificial upward draught is created, which materially assists in purifying our rooms in winter; and in summer, when there is no fire, the chimney acts as an air-shaft. But the fireplace in summer is too often closed up as tightly as possible with a fire-board. This is done for the sake of appearance, and no doubt generally in ignorance that appearance is consulted at the expense of health. The principle that double orifices are necessary for ventilation, should never be lost sight of. One of these should be as near the floor, and the other as near the ceiling, as is convenient, and they should also be placed, if possible, at opposite sides of the apartment.

Ventilation is even of greater importance during the night than during the day. More time is passed in the same atmosphere during sleep, than in our waking hours. The system is also more susceptible of noxious influences when we are sleeping. On these accounts the ventilation of bedrooms should be carefully attended to. Unfortunately an absurd belief still prevails that night air is dangerous. This belief we have taken some pains to aid in dispelling, in the chapter on "Taking Cold." Here we shall only add, that no air admitted from without is likely to prove half so perilous as that which is breathed and re-breathed by the unfortunate occupant of a small and tightly-closed bed-chamber. The great objection to open windows and doors, is the uncomfortable draught which is caused by them. This objection is with many persons insurmountable, and there are numerous contrivances for otherwise giving entrance and exit to the atmosphere. One of the simplest is to have a portion of the window filled by perforated zinc plates or with perforated glass. The draught caused by air entering through small apertures is diffused and rendered less perceptible. But ventilation by this means is necessarily very imperfect. Another plan is that by the revolving tin fan still to be seen occupying the place of a pane of glass in some old-fashioned windows. Ventilators made of plates of glass which can be opened or closed after the fashion of a Venetian blind occupy the same position in some modern windows. These are in every way superior to the preceding, as they do not interfere with the light and the current of air can be directed either upwards or downwards.

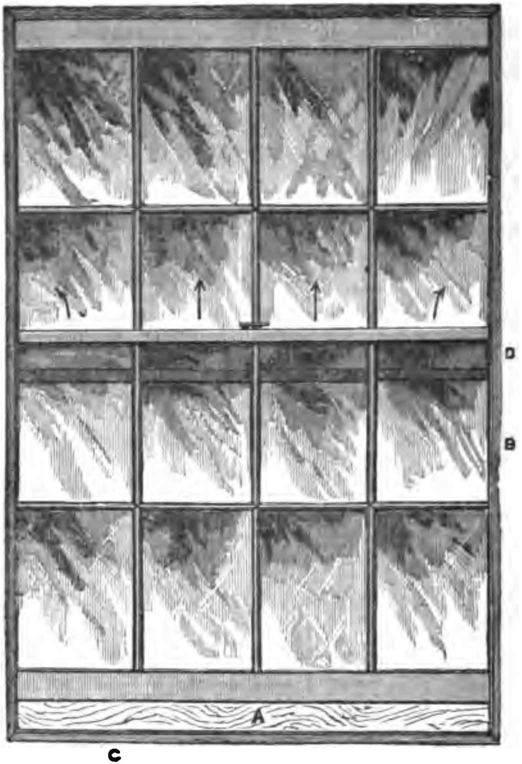
Ventilation from below is effected by means of air-channels and grated openings in the floor, but it is disagreeable on account of the draught thrown upon the legs of persons in the room. A better method is to have the skirting boards of the room arranged so that spaces for the transmission of fresh air shall exist between them and the walls.

Arnot's valve ventilator, which is inserted into the chimney at some distance above the fireplace, is valuable because it is self-regulating, as all ventilators should be as much as possible.

Several methods of ventilating from the roof are employed in factories, stables, and other buildings. One method is interesting because it depends upon a curious property of the atmosphere. It consists in inserting, perpendicularly, into the roof a tube, which is divided longitudinally by a partition. One extremity of the tube communicates with the outer air, and the other with the room to be ventilated. It is found that the foul air passes out through one part of a tube so divided, while the fresh air passes in through the other part. A tube inserted within another tube, with a space between them, is sometimes substituted for the divided tube. But the objection to both methods is, that at the ceiling the fresh current in its descent into the room mixes with the vitiated ascending current.

We have now to describe one of the best and simplest modes of ventilating ordinary rooms with which we are acquainted. It is one equally applicable in winter and in summer, because all draught is avoided; for even if a window be opened at the top, a downward draught is frequently felt, and in rainy weather it is often impossible to keep the window open. The present plan is applicable in all kinds of weather, and would be perfect if the ventilation could be effected nearer to the ceiling.

As it can be applied at an expense of a few pence, and as no unsightly appearance is made, it is equally applicable to the cottage and to the mansion. A reference to the woodcut will greatly assist our description. A piece of wood (A) an inch or more in thickness, three inches wide, and exactly as long as the breadth of the window through which ventilation is to be established, is to be prepared. Let the sash be now raised, and let the slip of wood be placed upon the sill of the window: the sash is then to be drawn down closely upon the slip of wood (A). If the slip has been well fitted—and the fitting may be made more complete by adapting it to the grooves in the sash and its frame, if any exist—no draught will be experienced in consequence of the displacement of the sash at this part. The effect of such an arrangement is, however, to cause a separation between the bars of the sashes at D. By this means perpendicular currents of air will be projected into the room between the glass in the upper and lower sashes and their respective bars, in the direction of the arrows in the engraving, and other currents will pass outwards in the reverse direction, in a manner by which all inconvenience from draught will be avoided.



Supposing that two or more windows at opposite sides of a room are fitted in this manner, a very satisfactory ventilation will be provided. Owing to a difference in its equilibrium, the air will rush in on one side and rush out on the other side of the apartment. If the slips of wood are painted of the same colour as the windows themselves, they will attract little notice.

We cannot conclude the subject of ventilation without an appeal to clergymen, schoolmasters, and others who are in positions of authority. Immense good may be done by impressing upon the minds of those over whom they are placed, the vital importance of breathing pure air. Especially should this be instilled into the young. It forms as yet no essential part of a liberal education, that a man should be taught to understand the conditions upon which he lives, or how he should best preserve his health. Such knowledge is certainly not less important than most of the instruction he receives. Yet all the knowledge which concerns his physical existence is left to be picked up by chance, or to be gained by experience, an experience sometimes only obtained by the sacrifice of health. The subtle causes which vitiate the air we breathe, must, as we have seen, be sought out to be understood. And if this kind of knowledge is important to those who live in large and airy houses, how much more important is it to those who pass their lives in humble cottages, and in the closely packed tenements of towns! How many headaches would be avoided—how many a pallid cheek would be tinged with the glow of health—how many drooping spirits would be roused to the enjoyment of life—how many sickly infants would be transformed into vigorous men and women, instead of being prematurely cut off by disease, were the simple facts universally known and acted upon, that no kind of stimulant is so permanently enlivening, no food more strengthening, than a proper supply of fresh air in our houses.

It is a pleasant reflection, that within the present century, owing to many causes, but chiefly to the advancement of science, longevity has greatly increased in this country. We feel assured that a very considerable increase is still to be effected by a more widely spread knowledge of the principles and practice of ventilation.

XVII.

THE LIVER AND ITS DISEASES.

THE importance of the liver in the animal economy is great. It is present in all classes of living creatures except the very lowest in the scale. Few people are aware that the large soft portion of that delicious and now costly edible, the oyster, is nothing more or less than a liver. In the higher animals, its dimensions, although much less in proportion to the entire bulk of the creature, are still considerable. In man the liver is the largest gland, and weighs about four pounds, or about $\frac{1}{36}$ of the weight of the body. It is formed by an aggregation of very small masses, called lobules, each provided with blood-vessels, together with little tubes for carrying off the bile when extracted from the blood by the minute cells of which the lobules mainly consist. These tubes or bile-ducts, by their union, gradually go to form larger tubes, until the contents of all are poured into a single tube which passes to the gall-bladder or reservoir in which the bile is stored up for use. The gall-bladder is capable of containing about four ounces of fluid; it lies under the right lobe of the liver, corresponding to a point a little to the right of the middle line of the body, and just below the ribs. This storing up of bile seems to be a convenience rather than a necessity, for the gall-bladder has sometimes been found, after death, to be quite obliterated, or else the entrance to it has been so blocked up as to render it practically useless. In certain kinds of animals too, such as in the horse and the deer tribe, no gall-bladder exists.

One of the uses of the organ is to separate bile from the blood. Certain carbonaceous substances are thus got rid of, and this is necessary for the purity of the vital fluid. But in the wonderful economy of nature, this otherwise waste material becomes subservient to the wants of the system. The bile is discharged from the gall-bladder by a duct which enters the small intestine at its upper part, just below its junction with the stomach. The secretion thus becomes mixed with the contents of the intestines, through their entire extent, and seems to be the natural purgative which prevents undue accumulation in the intestinal tube. Bile also prevents the contents of the intestines from fermenting. The operation of diverting the flow of bile outward through fistulous openings has been performed on dogs, and the animals have lived afterwards for years. The chief effects of such an operation are voracity, flatulence, and a putrescent tendency in the contents of the intestines.

Human bile is a viscid, greenish-yellow coloured fluid, having an intensely bitter taste. It is alkaline, and it is to the alkalies which it contains that the bile of animals owes its cleansing properties. Bile would seem to be concerned in the digestion of fat, but how it effects this is not understood. The quantity of bile secreted in twenty-four hours is estimated at between three and four pounds.

The liver is subject to several diseases in common with other parts of the body, as, for instance, inflammation, cancer, and abscess, but the results are modified by the peculiar structure of the organ. It is subject also to particular affections which are due to the operation of special causes. There are two things which happen in most such affections—either the organ enlarges, sometimes to an enormous degree beyond its proper size, or it contracts below it.

No cause is so productive of chronic enlargement of the liver as heat. The hot climate of India is so frequent a cause of this disorder, that to come home with a big liver and a heavy purse was a current joke in the palmy days of moneymaking in that country. By the slow influence of climate the organ becomes engorged with blood and its functions sluggishly performed. The result is seen in the muddy or even lemon tint of skin so characteristic of Indian residents, which is due to the imperfect elimination of bile from the system.

A preparation of liver (pâté de fois gras) is well known to epicures. But it is not equally well known that this delicacy is really the product of disease. At Strasbourg, where it is chiefly made, the geese from which the livers are obtained are subjected to the prolonged action of heat. It is alleged, on good authority, that the unhappy birds are nailed by the feet to boards, so as to enforce the necessary quietude during this inhuman process. But if the pleasures of the palate are the cause of so much heedless suffering, the unoffending creatures are not without some revenge. These diseased livers are far from being wholesome food.

The small or contracted liver in the human subject is usually the result of intemperance. The surface of the liver is covered by a stout membrane, called its capsule, and from this certain fine bands, or *septa*, pass through it between the lobules, so as to preserve the form and consistency of the organ. The effect of alcohol, absorbed from the stomach, upon these fine membranes is to induce in them a slowly-acting inflammation, by which contraction is induced. It results from this that the secreting cells of the liver are compressed and spoiled, and its surface, instead of being smooth and regular, becomes elevated into nodules, not inaptly compared to "hobnails" in appearance. This is also well known to anatomists as the "gin-drinker's liver."

In order to make it clear how it is that spirit-drinking is so injurious to the liver, it will be well to explain here the peculiarity of the circulation through the organ. Instead of being supplied with arterial blood, like other parts of the body, the blood which goes to the liver is collected from certain abdominal viscera, chiefly, the stomach, the intestines, and the spleen, into a large trunk, called the portal vein, by which it is conveyed to the liver, and then disseminated through it by means of the small vessels already spoken of. After having supplied the liver cells with the elements to form bile, this blood is again collected by the minute branches of the hepatic veins, which go to form two large trunks—the *venæ cavæ*—by which the blood is returned into the general circulation. Now when fluids are taken into the stomach, they are absorbed directly through their coats by the veins which are so freely distributed over the inner surface of the organ. In this way alcohol passes at once into the liver, and it is for this reason that the free use of simulants, when the stomach is empty of food, is so pernicious. It is a matter of common observation, that spirit drinking, after dinner is less injurious than drinking before dinner.

Alcohol mixed with food becomes in great part blended with and carried by it into the intestines. It thus becomes diverted into other channels, and, having been taken up by the absorbents, if only present in moderate quantities, becomes digested and made subservient to the support of the heat and nutrition of the body.

The form of liver disease just described is very fatal, and is often attended by dropsy. It will be easy to understand why this takes place by considering what has been said of the circulation through the liver. The obstruction presented to the onward flow of the blood, through the contracted liver, causes engorgement of the portal vessel and its branches. These last, in order to relieve themselves, exude through their sides much of the *serum* or watery part of the blood, which accumulates in the cavity of the abdomen. This, then, is the mechanism of this form of dropsy.

It is no uncommon thing for the bile to produce spontaneously, by a partial decomposition, concretions either in the larger ducts of the liver itself or more frequently in the gall-bladder. These gall-stones, as they are called, so long as they remain stationary, usually give little trouble, and are sometimes found present after death, even of the size of a walnut, without their existence having been suspected during the life of the individual.

It often happens, however, that when of moderate size they pass out of the gall-bladder through the short duct of communication into the intestine, and in this manner are got rid of. The calibre of this duct is about that of a crow's quill, and the necessary distension to admit the passage of a concretion the size of a cherry-stone is slow and painful. Perhaps, indeed, there is no suffering to which the human frame is subject which exceeds that which occasionally follows from this cause. The only consolation is, that, happily, gall-stone is seldom a fatal malady. On the other hand, a person who has once suffered from it is very apt to suffer repeatedly. A common effect of gall-stone and also of some affections of the liver is jaundice. The name of this symptom indicates its nature. The skin assumes a yellow tint, which is regulated by circumstances. It depends upon the presence of bile in the blood, and the depth of the tint varies, of course, according to the amount. But, in addition to this, those who have fair skins present a bright lemon-colour, while in the dark-skinned a greenish hue is presented. In some instances, however, the bile itself is unnaturally dark, and then the appearance of the skin is darkened in proportion; such cases seldom do well.

The yellowness of skin is sometimes attended by almost intolerable itching; but generally there is no sensation of the kind. The perspiration not unfrequently stains the linen bright yellow. The tears are yellow; but, most singular of all, sometimes the patient sees everything as if he were viewing all things through yellow glass. It proves that the humours of the eye, like the other fluids of the body, are tinged. To see things with a jaundiced eye is therefore no poetical fiction.

There are some curious statements connected with jaundice. *Icterus*, its scientific name, is the Greek term for the golden thrush, a bird having yellow plumage. Pliny informs us that the sight of this bird by a jaundiced person cured the patient, but killed the bird. It was called by the Romans the royal disease, as being one specially suitable for a king. Celsus, the famous physician of the age of Tiberius, tries to explain this. He says, it seems to be because, for the successful treatment of jaundice, all kinds of amusements are desirable, so that mind and body may be at the same time agreeably exercised.

It is a humiliating fact, that the human body is the home of many kinds of noxious parasites, which derive support either from the food we take, or else from the tissues of the body itself. Of the latter class is the so-called hydatid tumour, which is in reality a living animal which has been discovered in almost every part of the body. The liver, however, is its chosen seat, as it is found here far more frequently than anywhere else. Strange as it may seem, hydatids are immature tape-worms, which, in the perfect state, are not more than a quarter of an inch in length, and inhabit the intestines of our domestic dogs. The eggs of these tiny, but far from harmless creatures, gain access to our bodies in the water we drink, or by some other means. It is not our purpose at present to follow the egg through the changes it undergoes, or the conditions necessary for the production of the perfect worm. It will be sufficient to state that the egg, having lodged in the liver, becomes developed into a bladder-like tumour, containing a clear fluid, and that it may attain the size of a cricket-ball, or even larger dimensions. It can be well imagined what a serious injury such a tumour must cause to the liver. Fortunately, in this country the disease is comparatively of rare occurrence. Nor is it necessarily one incapable of relief, and even of permanent cure. The tumour is sometimes tapped by the surgeon with complete success. Nevertheless in Iceland, where, from local causes, the disease is extremely common, it is the source of a large proportion of the total mortality of the island.

Having now given a rapid sketch of the more serious diseases of the liver and its appendages, we have a few words to say about those which are, in a popular sense, more important, because more common, and because great mistakes are constantly made on this subject. Functional disturbance of the liver, as known by diminished or irregular secretion of bile, is certainly not unfrequent. Sometimes this is associated with pain in the right shoulder, a sense of fulness and tenderness on pressure under the ribs on this side, with or without the presence of a tumour in the same position, showing the liver to be enlarged. These symptoms especially belong to persons of a certain aspect—sallow, sunken-eyed looking people, ordinarily termed bilious subjects. But nothing is more common than to hear people say that they are *bilious,* which means, if it means anything, that they are suffering from some fault in the quality or the quantity of the bile. It must also be admitted, that many members of the medical profession too often apply the term carelessly, or else adopt too hastily the statements of their patients. The fact is, that in nine such cases out of ten, it is simply the stomach which is misused. Healthy people oppress their stomachs by eating and drinking a greater mixture of things, and in greater quantity, than they can possibly digest; or else, the digestive power being weak, they indulge more in the way mentioned than the stomach is able to receive without injury, although, if healthy, no bad consequences would result. In either case various unpleasant sensations are complained of, and the whole is summed up by declaring, as already said, that they are "bilious." Now there is a traditional notion that a "blue pill and black draught" are the only true remedies for biliousness. The pill, as most know, consists of mercury, and the draught is a strong purgative consisting of senna and Epsom salts. This rough treatment relieves the effects of accidental indigestion, that is to say, of indigestion induced by excess in healthy persons. But its frequent repetition is very injurious; inducing permanent disorder of digestion, besides other bad results that attend on the introduction of mercury into the system. It will be seen that the misuse of terms is here, as in many other cases, a serious evil. The best of all courses in such ailments as those last mentioned, would be avoidance of the exciting causes. But when people attribute to the harmless liver what is in reality due to the stomach, it does not occur to them to be as careful about diet as they would be otherwise. So with regard to immediate treatment; while abstinence, in order to rest the stomach, and at most some gentle aperient to remove offending materials without violence to the organs, would be only necessary, the blue pill and strong draught are swallowed because custom, and sometimes the doctor, requires that the assumed biliousness must be met in this particular manner.

We have said nothing about the treatment of diseases of the liver, because, as a rule, they require measures only to be undertaken by the medical practitioner. Mercury in judicious hands is undoubtedly a valuable agent in this class of diseases. Nitro-muriatic acid or *aqua regia,* that active agent which dissolves gold itself, is also highly useful. Amongst the more harmless drugs, and one which may therefore be used freely by the unskilled, *taraxacum,* which is extracted from the dandelion of our fields, holds a place. The freshly expressed juice of the herb may with advantage be substituted for the prepared drug.

XVIII.

THE ACTION OF ALCOHOL.

OUR object in this chapter will be to teach the physiological effects of alcoholic liquors, in order to afford guidance in use of alcohol; and to exhibit the changes wrought in the human body by spirituous liquors taken in excess, that alcoholism or the abuse of alcohol may be understood.

The health both of the individual and of the State begins to excite some little national solicitude; but the appeal to State interference in such matters, must come at last from the people themselves. It is easy to make laws, but difficult to enforce them, unless the large majority of the nation understand the benefits to be derived from obedience. But we are not in the ranks of those who would remove the tax on spirits: a tax whereby the poor as well as the rich are made to contribute to the expenses of Government by paying a price above its production cost for an article of luxury; and very far are we from siding with those who misinterpret the liberty of the subject to mean the right of any man to wrong his neighbour; to sell him fictitious goods—poison perchance for food.

Need we preface our remarks further? Yes; lest certain persons, wearied by the repeated bugle calls blown by the trumpeters of total abstinence armies, should shoulder arms and march away from us. We are no abstainers ourselves, and we are not about to advocate teetotalism under the banner of physiological instruction. It is as Physicians we speak; the flag we hoist has a white ground with a broad red cross upon it; we hold ourselves aloof from the fray; both armies send their shot into our tent; if we are attacked we know it is by ignorance or misadventure; we succour both parties alike.

Come, tell me, cries some philosopher, a poser of questions, "Is alcohol food or poison? for herein lies the gist of the whole matter."

Nay; not altogether, we think. But those who ask us questions will get questions also in return. Can alcohol fail to be a food when in states of habitual intemperance, in diseased conditions of the body, as in fever, a man lives sometimes for many days together upon spirit and water alone? Surely that thing is rightly called a food upon which life can be maintained.

Arguments clinched thus easily by superficial questions mutually leave both sides dissatisfied. We had better far give up the time, and work out the problem we seek to solve by studying the facts together.

We must premise a few words upon the composition of alcohol; we shall then follow its journey through the human system, noticing its way of entry, distribution, appropriation, decomposition, and separation from the body.

Hydrated oxide of ethyle is a chemical synonym for alcohol. It is the substance formed when ether and water are made to combine with each other, which under fixed chemical conditions they will do; or, practically, when any substance containing sugar or glucose is fermented, or broken up by the decomposing action of the yeast plant growing in it. The living vegetable, undergoing change itself, disturbs the elements—the carbon, hydrogen, and oxygen—of which the sugar is composed; and these proceed to re-arrange themselves as carbonic acid and alcohol, volatile oils and acids.

The fermenting liquor called *must* in the instance of grape juice, *wort* when the saccharine principle is derived from some grain, furnishes always those two chemical products, carbonic acid and alcohol; the former passes into the air or is partly held in solution by the mother liquor, the latter, alcohol, is capable of separation by distillation. Being more volatile than water, spirit distils over, and is most pure in the portions that distil over of the animal is maintained, the maltreated portion ulcerates.

When, however, diluted alcohol is used, and any tissues are thus rendered more vascular, they become warmer, because more blood passes through them, and the blood-cells themselves swell in size by reason of the alcohol and water permeating the walls of the vessels and passing into the current of the circulation.

Alcohol, then, if sufficiently diluted, quickens and replenishes the circulation; if too strong, it acts upon living as on dead tissues, absorbing or appropriating the water of which they are composed and coagulating their albuminous contents. The throat and stomach are protected against the coagulatory action of strong spirituous liquors by their surface moisture, and the free and constant flow of blood through their interstices, which yield water by exhalation until the spirit is diluted enough to admit of being absorbed into the veins.

It is astonishing how far the force of habit goes in enabling soft and vascular tissues, like those which line the throat and stomach, to sustain the assault of a fluid strong enough in alcohol to be readily inflammable, and which would shrivel them up if kept long undiluted in contact with them.

Alcohol passes into the blood direct through the walls of the smallest vessels. It cannot be fairly said to be digested. It suffers little if any chemical change by being mixed with the digestive juices of the stomach and intestines. It is not absorbed through the same channels whereby the food gains access into the blood. The *villi* do not take it up; the lacteals contain no appreciable trace of it. It is carried, diluted but unchanged, through the veins into the liver, and thence into the heart and through the lungs, and thus into the arterial circulation.

Let us now watch a little more closely the effect of alcohol in the blood. First, upon the blood-vessels themselves—the pump and pipes by which the circulation is effected—and then upon different organs through which this blood is conveyed.

We have observed that the blood-cells are rendered slightly larger by being bathed in a diluted alcohol-containing fluid; the blood-vessels are also somewhat dilated by accession of more fluid into them; the heart's action becomes quickened, and its contractions take place not only more rapidly but with increased vigour. The blood is driven more quickly through the lungs, and the respiratory acts are proportionably accelerated. We have only to watch the face of a person who has drunk a full dose of wine or spirits, to verify all these things. The smaller blood-vessels in the cheek, or those which traverse the white of the eye, lie open to inspection; the face becomes flushed because these are more turgid, the eye is injected from the same cause; while the fact of larger blood supplies being conveyed to the surface of the body is further testified to by a very slight elevation of the skin temperature at the extremities of the body, which a sensitive thermometer will show.

The general sensation of warmth and well-being perceived shortly after a dose of alcohol has been taken, admits, then, of ocular demonstration. If the blood, however, be overloaded with alcohol, the surface temperature of the body falls.

We turn our attention next to the effect of the spirit upon the organs through which it passes.

The veins which absorb the diluted alcohol from the stomach and intestines, carry it directly through the liver. This organ, therefore, sustains the first and heaviest assault of the strongest alcohol and blood mixture; and if alcohol be injurious to the economy, this viscus will suffer accordingly, a circumstance we may have occasion to revert to and prove hereafter.*

When the blood, thus laden, reaches the air-cells of the lungs, a considerable quantity of spirit is exhaled in the breath. The volatile oil mixed with it gives the expired air the smell of the liquor drunk; but the actual presence of alcohol admits also of experimental demonstration. If the breath of a person who has drunk so little even as a glass of light ale, containing three per cent. only of spirit, be conveyed through a test solution of chromic acid, the presence of alcohol can be attested by a distinct colour change.*

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* Few of our readers, we think, will fail to have heard of the gin-drinker's liver. "He died of dropsy and diseased liver, a' from the drink."

That the alcohol drunk has gained access to every part of the body through the medium of the blood, can be shown by its detection in the sweat and in the urinary secretion. By all these portals, then—the lungs, the sweat-glands, the kidneys—the alcohol is slowly eliminated. As to the quantity which thus escapes, the quantity appropriated as food and consumed, and the quantity merely combined and stored away, we possess as yet unfortunately no exact information.

Part of it, we know, is carried off through the alimentary canal as waste,—is never therefore taken up into the blood at all; but the greater part by far is absorbed into the circulation. Of this a portion is exhaled, a portion also is excreted by the channels above mentioned; but a portion, and this a large one too, we believe, is broken up into water and carbonic acid, and thus consumed, as Liebig originally surmised, either in the blood, by the action of the red cells, or in the liver, or in the nutrient changes in the interstitial tissues of the body, perhaps in each and all these places; or, if not thus consumed, it is converted into fat, and thus appropriated to the uses of the economy.

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* The exact composition of this test-solution is one part bichromate of potash in 300 of pure sulphuric acid. Its delicacy is so great, that the presence of $\frac{1}{180}$ of a grain of alcohol can be detected by it.

Although taken into the circulation rapidly enough, alcohol is but slowly eliminated from the system, and is probably only very slowly appropriated. Particular organs or tissues of the body exhibit especial affinities for it. They seem to hold it as a sponge holds water. The brain and nervous tissues, the liver, and the blood seem specially capable of holding or storing it; so that if an animal which has been overdosed with spirits be killed some hours later, and its body examined, not only do the brain, liver, and blood smell strongly of the spirit administered, but this can be recovered from them again by a process of distillation. The relative quantities of alcohol which equal weights of these three tissues thus furnish, prove that the brain substance holds more alcohol than the liver, and the liver more than the blood—a circumstance of extreme interest when the effects of chronic alcoholism come to be considered.

Two physiological effects, distinct and opposite, have been attributed to alcohol—an early stimulant, a later depressent action. To explain these, several theories have been mooted. All excitation, it was said, means more rapid oxidization, quicker consumption of nutrition, greater wear and tear of tissue: if the heart's action at first be quickened by the stimulant action of alcohol, this organ must shortly suffer fatigue, the circulation will then become retarded, and the sense of depression be felt. Similarly, of the nervous system it was affirmed—exhilaration means what our American cousins call rapid brain-functioning, living too fast for repair; for the nutritive processes require time, and cannot be carried on so quickly as the expenditure of force.

There is something true in the theory thus ennunciated, and framed no doubt to meet the occasion. Fatigue does follow over-exertion of mind or muscle, and is evidence that the processes of repair have not taken place so quickly as those of destruction. But the idea that life and energy are antagonistic things involves fundamental error. Energy, or the manifestation of power, the conversion of force into action, involves no expenditure of life or loss of power. Thinking or lifting a weight is but a function of tissues provided to issue thoughts or actions. The tissues do not suffer by reason of their employment, so long as their nutrition is maintained. Brain and muscle can be very fairly likened to machinery, instinct with power but requiring nourishment, as the engine needs fire and water in order to be put in motion. Both require food in order to perform their functions; but there is this difference between them—the engine may lie by, yet not suffer, but the nutrition of brain or muscle is requisite that these may live; and perfect nutrition—the appropriation of what is needful, the removal of what is harmful—cannot be maintained unless the organs themselves be exercised.

The employment of his mind or of his hands does not wear the life out of a man, except the work be performed under conditions for which the machinery was never constructed. The human body was made for labour, and parts which are not employed quickly degenerate; indeed, we believe more men wear out through indolence than by strain of overwork.

But to revert. The temporary exhilaration conferred by alcohol is termed its stimulant effect; a sense of well-being is diffused all over the body by the greater fulness of the blood-vessels and a more equable distribution of animal heat. Nor is this sense of comfort followed of necessity by any depression, so long as the alcohol has not been taken in any excess; if, however, it accumulate to any extent in the blood, the nervous tissue suffers impaired nutrition, and exhibits its fatigue by mal-functioning.

As we shall hereafter have occasion to insist, alcohol cannot be called anything else but a food, for it contains certain elements by which the body can be sustained; but it is not difficult to show that it is a dangerous food, and one that should be very sparingly employed.

Itself a feebly oxidized body, its desire is to combine with oxygen, until, as chemists say, it obtains more chemical stability, or is decomposed into water and carbonic acid.

Now alcohol mixed with the blood conducts itself in no way differently to alcohol in the chemist's laboratory; and just in that degree in which the blood is loaded with alcohol, it may be pronounced to be deprived of its free or combinable oxygen; it is more highly carbonised, more charged, that is, with carbonic acid, more venous, and less capable of effecting those chemical interchanges which render it the medium by which nutrition is carried to each remote corner of the body, and by which the bodily heat is maintained. Now a highly nutrient blood, one that can yield its oxygen liberally, is essential to the vitality of the brain and nervous centres; these cannot perform their manifold functions unless they are well nourished. I have not space to dwell upon the evidence of this, but the fact is one well recognised by all physiologists.

The enervating influence of close, ill-ventilated rooms, and the drowsiness induced by the respiration of atmospheres overloaded with carbonic acid, are homely but apt examples of this susceptibility of the brain to suffer in its nutrition.

If an animal be deprived of oxygen, if it be exposed to an atmosphere surcharged with carbonic acid, its blood quickly becomes purple coloured, and fails to nourish the brain. At first the creature becomes drowsy, then comatose, is not infrequently convulsed, and finally dies asphyxiated, the heart gradually ceasing to act because the circulation through the lungs has come to a stand-still.

Laughing gas, chloroform, ether, alcohol, all procure anæsthesia, with different rapidity it is true, but by one common action, depriving the cerebral centres of the oxygen essential to their nutrition, and poisoning them with the carbonic acid whose quick removal is equally needful to hinder disturbance of their functions. That anæsthesia is produced in intoxication, any one who has seen a drunken man fall and cut his face, or strike his knuckles against a wall will be ready to believe.

Alcohol then deprives the blood of its free oxygen, and, in consequence, the brain suffers partial paralysis of its functions, chemical interchanges are diminished all the body over, combustion is retarded, and the animal heat is depressed.

We proceed next to examine the symptoms of that peculiar brain paresis, or palsy, which is produced by alcohol in the circulation, since the manner in which the higher intellectual operations of the mind are first assailed, then starved, and finally annihilated, while the lower situated nerve centres exhibit greater powers of resistance to the evil effects of a partially de-oxidised blood, is of great physiological interest.

Among the facts which the physiologist for many years past has been in a position to deduce inferentially, none have appeared to him more important than those which led him to attribute different functions to different portions of the brain and spinal cord; the exact allotment of their duties to the several parts was, however, by no means an easy thing to determine. The experiments made involved rude injuries, and were but rough guides to truth; latterly, however, a new mode of questioning nature has been discovered; what was formerly guessed at has been established upon more reliable proof, and much which could not be ascertained by the older methods is likely to be made known to us.

It appears certain that some portions of the brain substance are set apart by habit, and, as it were, educated to preside over particular intellectual operations. Thus we are fairly entitled to conclude that there is a thought-apparatus, which furnishes ideas, remembers, compares, judges, exercises control over the emotions; that there is a receptive apparatus, which receives and stores impressions derived from the special senses, which feels, smells, sees, hears, and tastes, through organs provided for these several purposes.

Then again, there are nervous centres whose duties are to co-ordinate complex muscular movements, as of the two eyes, that vision may be single; as of the tongue, that speech may conceal and reveal the thoughts; as of the hands, that those may wield a pen or play a piano; as of the legs, that those may poise the body in running or standing; as of the trunk, that the upright position may be maintained.

And lastly, we must make mention of those lower situated nerve centres which co-ordinate the movements of respiration and the rhythmical contractions of the several cavities of the heart. It will be perceived that the human body is like the Prussian Government, a very perfect bureaucracy; its direction offices are manifold; each has strictly defined duties to perform, all have to report progress and to receive orders from one presiding head-centre.

After this apparent digression into general physiology, we may proceed to illustrate the several phases of intoxication or brain-poisoning with alcohol, with some hope of making them intelligible.

One of the first, if not quite the earliest symptom which can be accepted as evidence that certain nerve functions are impaired by the circulation of a blood oppressed by alcohol, is flushing of the face and of parts of the skin. The same thing is observed in blood-poisoning during fever. The interpretation of this phenomenon usually given is a partial paralysis of the cranial and cranial sympathetic nerves, whose branches are supplied to the walls of the arteries, and whose duty is to adjust the blood supply to the requirements of nutrition.

This symptom is seen equally in intoxication by ether and by alcohol: certain blood-vessels become dilated, more blood passes through them, and the skin surface supplied by them becomes flushed, and exhibits a rise of temperature. A rise of 3½° Fahr., as Dr. Anstie's experiments show, can thus take place in the ears of rabbits and guinea-pigs.

Simultaneously almost, due perhaps to the same cause, the eyes are perceived to be slightly protruded from the sockets, and obtain a brilliant glistening look. And now it is (in human kind) that the hold which a man's judgment ought to exert over his imaginative faculties begins to be relaxed, and the phenomena of nerval excitement are exhibited: ideas follow each other quickly, and exhibit exaltation or depression according to a man's habit of thought; his tongue, too, is loosened, and becomes an excellent index of the degree in which mal-nutrition of his intellectual brain-centres has influenced the operations of the mind. He brings little Egomet into the foreground; it is self-praise, self-depreciation, his mother wit, his natural talents, his proverbial luck, his personal endowments or adornments, but self, self, self is the character that never quits the stage. He is precise, communicative, loquacious, garrulous, twaddling, and at last babbling in his talk.

It is of course in this semi-delirious condition that different natures show themselves, illustrating the *in vino veritas*, of which so much has been said: how the gentlest creature alive becomes doggedly authoritative and provokingly contradictory; how the timid man is emboldened to adventure; how the individual to whom reserve was habitual, lays bare his profoundest secrets to the friend of an hour's acquaintance.

In this stage of intoxication, it is not that ideas are wanting any more than muscular force, but that the faculty of co-ordinating those complex intellectual operations, which together make up the mind and character of the individual we were wont to know, is faulty; judgment is impaired before memory, emotional control is lost, and the passions stalk forth,—the moral sense and power of voluntary recollection are lost. The well balanced Egomet has lost all the benefit of its worldly schooling. The coarse vulgar foundations, upon which a highly finished superstructure had been reared, crop forth to our disgust; the lower nature has predominance.

Further evidence that all this is the result of partial paralysis of one portion of the brain-substance before another will be shortly forthcoming. But a fact in illustration may be advanced. In man as well as in animals, more or less anæsthesia of the skin of the face accompanies, we are told, an early stage of intoxication; it is due to a partial paralysis of the fifth cranial nerve, which supplies sensation to these parts. The skin about the muzzle of dogs loses common sensation. The affection of the cranial sympathetic, as evidenced by the flushing of the face, we have already dwelt upon; while so soon as the stage of alcohol narcosis is reached, the hypoglossal nerve, which co-ordinates the movements of the tongue, becomes partly paralysed, and speech is affected.

The stage of intoxication which is characterized by cerebral mal-nutrition and nerval excitement passes, by insensible gradations, into that of narcosis, or drugged sleep. The special senses, taste and smell, become impaired somewhat early, so that a connoisseur cannot distinguish one wine from another. The eye, too, loses its cunning, its muscular movements, like those required of the tongue in speech, failing in that exquisite adjustment and harmonious working which is requisite for single and perfect vision; the nerve centres, whose business it is, without any effort of volition, to balance and control that delicate motion, being either partially or wholly palsied.

Curiously enough, as in the delirium of disease, and in the mal-functioning provoked by the mal-nutrition of insanity, the organs of vision are far more prone to play their owner tricks—see that which is not, and misrepresent that which is—than either the sense of hearing or that of touch. Thus for a long time after a drunken man's speech has ceased to be articulate, or his eyes to convey correct impressions, he may be induced to gather his semi-consciousness together at hearing his own name called.

In our description of the physiological effects of alcohol, we have now made our readers acquainted with three stages: a first, of stimulation, a second, of delirious excitement, and a third, of narcosis or partial brain palsy. This palsy may become more and more profound as the paralytic influence extends over the nerve-centres which control the movements of the limbs, and administer to the functions of mere animal existence, such as the respiration and blood circulation; but it is desirable to separate this state of advanced palsy from that of narcosis, and to call this a fourth stage, or stage of coma.

Throughout the stages of stimulation and excitement it appears certainly the rule that the skin is hot and drier than natural; but when the narcotic stage is passing towards that of coma, a sensible perspiration usually bedews the forehead and cheeks, and this becomes apparent just when two other usually associated symptoms are observed, namely, giddiness, or vertigo, and vomiting. During the stage of narcosis the pupils are natural, or rather contracted; but in that of coma they become dilated. It is in the stage of narcosis that the power to regulate the movements of the legs becomes impaired, but the power to support the body is not wholly lost until the stage of coma is reached. In cats and dogs made drunk with spirit, the same series of physiological symptoms are manifested that are observed in man. The hind legs first lose power, and the animal struggles to stand; finally they give way altogether, so that the creature falls, paralysed both as to power of motion and sensation in those parts, while still retaining sense to struggle forcibly with its fore limbs. Thus a drunken man is often seen supporting himself by his arms when his legs are perfectly useless to him.

It is in the stage of narcosis that convulsive movements not infrequently affect the muscles of the arms and face. When an animal falls down from paralysis of its hind legs, drowsiness overcomes it; a like thing is seen in the intoxication of man: he falls asleep, and will sleep for some hours a drugged heavy sleep. This is not necessarily coma, in the physiological sense we attach to the term.

All intoxication does not reach the stage of coma, which is vulgarly called the state of dead drunkenness. This condition is exactly similar to that produced by an overdose of chloroform, and is one, of course, of imminent risk to life; in it a man lives only by the pertinacious resistance to poisonous impressions exhibited by the great ganglionic nerve centres, situated at the uppermost portion of the spinal cord. We shall describe the symptoms most characteristic of the stage of coma, which ought to be better known than they are, for not a few persons are allowed to die in police-stations and elsewhere every year, those who pick them up not recognising the symptoms of most dangerous import, which serve to distinguish this state from that of mere intoxicated sleep or narcosis.

In the stage of coma, the pulse, previously full and slow, becomes small, running, and almost imperceptible; the face is pale, the surface of the body cold, for the bodily temperature is now universally depressed. If the arm be pinched, it is not moved; if the eyeballs be touched, the eyelids are not winked; respiration becomes slower and slower; the lips become livid; and death, if this takes place, happens either by syncope, the heart ceasing to beat, or, as is more usual, by failure of breath through gradual stagnation of the circulation through the lungs, in which case the lungs after death are found gorged with blood, and the right half of the heart is fully distended.

People have been said to die of cold in this comatose stage of intoxication. This much is certain, that external cold has the effect of quickening the process of intoxication; as is well known, a man who was previously only slightly excited by liquor, by going out into the cold air in frosty weather may quickly fall in a state of narcosis, become comatose, and die.

Furthermore, in the stage even of narcosis, the circulation of alcohol through the brain-centres certainly has the effect of lowering the temperature of the body. It is scarcely true, however, to conclude that the man who is found dead in the open air, and who is known to have been drinking previously, has died from the effects of exposure to cold alone; rather should it be said that he has died from the poisonous effects of an overdose of alcohol promoted by external cold.

To recapitulate: we have described four physiological stages of alcoholism, not strictly limited, seldom distinctly observed, for the one verges by scarcely perceptible gradations into the other.

For its stimulant effect, in extreme fatigue, in disease, and especially in fever, the physician employs wine or brandy to steady the heart's action and invigorate its contractions; he perceives that the alcohol is useful in diminishing perspiration and excessive secretion in states of great weakness, that neuralgic pains are relieved by it, and tremor and spasm of muscle are temporarily abated.

But it is not merely for its stimulant effects that he prescribes, and allows, the sparing and careful employment of alcohol-containing liquors.

Nearly all of them, as wine and beer, contain other nitrogenous materials as well as alcohol, and are strictly foods, with just that amount of stimulant combined with them which makes digestion easy and nutrition more complete. The man who gives up taking beer or wine with his food can maintain himself quite well without them, but he will eat more bread, more meat, and more vegetables, and he will require more time for his meals, being able to exert himself neither quite so quickly nor so vigorously after them.

But all alcohol-containing liquors are foods to be taken with discretion and extreme caution. It is not every habit of body that can bear them at all. They are foods which should be reserved for extraordinary service, for special conditions of disease, and for impaired health. They are truly serviceable only when nutrition is disordered, when one part is living too fast, another too slowly, when a man is suffering from some disturbance of his normal balance, or when he is maintaining life upon conditions unfavourable to health.

That fermented drinks are useful articles of food, the history of man upon the earth, who has certainly employed them from the earliest ages and not deteriorated under their habitual use, as well as the universality of the instinct which has prompted mankind to consume them, may be held to testify.

Strong liquors and spirits, even the stronger wines, may find their fitting place as medicines, but as articles of food cannot be regarded as other than dangerous; and this because the quantity in which they can be taken without producing harm (the dose, that is) will be found to vary with climate, temperature, and the individual state. The stronger any liquor is in alcohol the less claim has it to be called a good food itself, and the more certain is it to diminish the appetite for the more valuable flesh-making nitrogenous materials which ought to enter into any dietary calculated to maintain all the organs of the body fully repaired.

There is a habit of petty drinking which we must notice here to condemn. It is vulgarly called *"nipping."* The very name has a mischievous clink about it, implying sharp twinges made on a sudden.

Both men and women practise it,—men at their offices or at their work, ladies in the midst of their domestic duties, or at their amusements. The fatigue of overwork, the *ennui* of mere indolence, alike prompt to it. Men usually employ a glass of sherry, women take ether, eau de Cologne, or sal volatile; but the object is one and the same,—to goad what have become, through lack of healthly nutrition and fair treatment, torpid nervous energies. The individuals who thus resort to alcohol for its influence upon their nervous systems fall into the vice of dram-drinking almost unawares.

One, at least, amongst the many risks attached to fermented liquors, as adjuncts to other food, is their quick assimilation, their very easy appropriation by the body, and the facility with which they staunch the sense of hunger. Thus they are employed often to save time, which a more solid meal would require in consumption; and the principal meal of the day, which can never be dispensed with if health is to be consulted, is postponed until the evening, when the body is fatigued, and requires repose rather than food, and certainly rest before taking it.

The professional man who, after a day's fatiguing brain work, comes home to a late dinner, has more relish for wine than food; so too the labourer who has foregone his mid-day meal, and taken ale in lieu of it, sits down with little appetite to bread and tea, or meat, but craves for spirits, which will relieve his immediate sense of lassitude, but can scarcely refit his frame to endure another day's labour.

But spirituous food in such cases is attended by risks of all kinds: first, there is the temptation to take the alcohol mixture stronger and stronger, that the sense of fatigue may be more quickly subdued; then there is the inclination to drink liquor before any food is put into the stomach, by which the process of digestion becomes impaired; and lastly, there is the great likelihood that an excess of liquor will be taken, for while the nutrition which is required is quickly furnished, the sense of refreshment which is derived from a natural meal composed of varied aliments is not obtained; thus the individual is prompted to take more alcohol than his body can with safety support and appropriate, and he severely tasks his eliminant organs in removing, not merely the daily waste of his tissues, but an excess of wasteful food. This, too, without even approaching to a manifestation of the symptoms of intoxication. It will be readily understood that the bodily coffers are loaded without being enriched by treasure of this kind, and that by the help of alcohol, taken not as a sparing adjunct but as a main staple of food, a man will be encouraged to live upon the capital of his physical energies instead of on the interest; interest which his organs, more fully nourished by other aliment, would have liberally furnished him.

All foods are stimulants, and all stimulants are foods, and the distinction sometimes drawn between them is not merely fanciful but strictly untrue; furthermore, we might inculcate a doctrine that we are well aware every physiologist would endorse: That any food taken in excessive quantity is a poison, that is, acts prejudicially to health, disturbs and damages the body.

Before concluding this sketch of the physiological effects of alcohol, there is a matter which we feel it our duty to insist upon, namely, that while all alcohol-containing liquors are dangerous foods, and for the great mass of mankind are quite unnecessary, yet as medicines they are fraught with special powers, and possess qualities of such value as need to be pointed out,—this, too, especially at a time when we hear of the institution of a hospital where no alcohol is to be admitted.

Alcohol in the blood, as alcohol outside it, is an antiseptic agent of singular power. In states of blood-poisoning and fever it lessens the tendency of the blood itself to break up, and of the living particles, the cells in it, to disintegrate; it promotes the consolidation of the tissues of the body, when these are prompted by some fermenting disturbance, as in fever, to swell up and incorporate more water than they require. It, further, in fever retards that very consumption of tissue which constitutes the pyretic or febrile state, arresting, as we have shown, all chemical interchanges between the blood and the tissues, by its own more vigorous action as an oxidising agent.

Magnus Huss, in his work on Alcoholism, classifies individual temperaments according to their several proclivities to exceed in drinking, and to suffer from the action of alcohol. First, because most mischievously affected, he places the sanguine nature; second, the bilious; third, the lymphatic; and last of all, the nervous.

It is well known that the inhabitants of cold and damp northern climates are, in respect of consuming liquor, the chief sinners; the Italian and Spaniard, inhabitants of hot and sunny climes, and living beneath blue skies, being broadly and generally speaking sober people. Their energies are perhaps too active to need further stimulation.

Our own experience has taught us that the temperament which in this country appears most prejudicially affected by alcohol is the sanguine. Plethoric persons, although strong-headed, and able to carry, as is said, unusual quantities of spirit without being intoxicated, exhibit small power of self-control in drinking, and suffer accordingly.

Those again who inherit an unstable mental equilibrium, irritable, excitable persons, and epileptics, should abstain from alcohol as rigorously as from very poison. Contrariwise, the lymphatic, the over-large, pale, apathetic personages find good wine and beer, not only their best medicine, but a useful adjunct to their dietaries.

There are writers who attribute all the ill effects of alcohol to the impurity of the liquors drunk, the amount of fusel oil, œnanthic ether, volatile oils, and acids in them. These people remind us of the *bon vivants* who attribute their headaches and parched tongues to the soup, the fish, or the sweets.

That certain adulterations and impurities, which provoke thirst, and so excess in drinking, are wickedly pernicious, we are quite ready to concede; but that fusel oil is the principal deleterious agent in spirits, or that the brain suffers especially from it, and not from the alcohol, we see no reason for believing.

But into the long category of more or less poisonous alcoholic mixtures we have no intention to enter. There are tinctures of certain herbs, as absinthe, and liqueurs, as vermouth, which it is likely enough exert some special deliriant effects upon the brain, acting in this particular like Indian hemp, henbane, stramonium, belladonna, camphor.

Some wines inebriate more rapidly than others; others deteriorate the digestion especially. Light sparkling wines make people cheerful and talkative, heavy wines and beers render them morose and sleepy; but these are general facts which we have not time or right to discuss more minutely under the action of alcohol

XIX.

MUSCULAR MOTION AS EXEMPLIFIED IN THE HUMAN BODY.

There are two things in which most men believe—*force* and *matter;* but the one is so intimately blended with the other that, apart, we can hardly, if at all, recognise them. Now, of late years, since the sciences called the natural sciences have been more and more studied, men have set themselves to work to investigate what is called force, and have found that what were formerly held to be separate and distinct forces [or, as people then preferred calling them, imponderable bodies, that is to say, substances which could not be weighed, and which had none of the other ordinary properties of matter], were in reality identical, and that one force passed into another kind of force, insensibly it might be, but not the less surely on that account.

To take an example: formerly men held electricity, magnetism, chemical force, heat, light, and motion to be things totally different and distinct. Now-a-days most men look upon these as one and the same, modified variously but still identical; so that either can take the place of the other. As the simplest of these, motion has been accepted as a kind of starting-point, and hence all the various forces we have mentioned above, as well as certain others we might name, are held to be *modes of motion*. Everybody has heard of the plan adopted by some savage races to kindle their fires, when live embers are not to be had, and where lucifer matches are unknown. They rub together two pieces of dry wood until one or the other takes fire, and thus effect their purpose. Now, what have we here? We shall not yet speak of the changes within the body which movement implies, but, starting with the motion given to the two pieces of wood, we see how motion gives rise to heat, how heat ends in flame—that is, light-giving chemical change—and so on; for with chemical change begins a new series. Thus, when two metals of opposite characters are acted upon by compound substances, like oil of vitriol, or aqua fortis, or blue vitriol, chemical change goes on and electricity shows itself, as in the ordinary galvanic batteries, which are now familiarised to the public at the different telegraph stations. Electricity, in its turn, acting on a bar of soft iron, makes it a temporary magnet, which has the same powers for the time being as a loadstone. Electricity may also easily be converted into light and heat, as in the electric light which is now used as a beacon to sailors at Dungeness and other lighthouses; in the better known and far more dangerous form of lightning; and in the sparks which may be drawn from the back of a cat by stroking her fur the wrong way on a frosty night. A more common illustration of motion converted into heat and light is seen when, by the friction of a long run, the axle of a railway carriage sets on fire the carriage to which it is attached. So much, then, for illustrations of the change of one kind of force into another. Now we must speak of those which take place within the human body.

In the human body, as in all other machines, every movement implies a chemical change; for wherever force, of whatever kind, makes itself apparent, there is change at the same time. As to the different kinds of change within the body, we do not now speak; we only deal with that implied in muscular motion.

What, indeed, we chiefly wish to do, is to illustrate the mechanics of the human body; to show, in other words, how much of the *machine* enters into its constitution and its various actions. For our purpose, no more apt comparison can be drawn than that which is afforded by the steam engine, to which, indeed, the human frame presents many analogies. In the first place, then, we may assume that the steam engine is composed of certain masses of iron, steel, and brass, arranged in certain definite forms, whilst the human body, from our present point of view, may be assumed to be made up of certain bones, muscles, tendons, ligaments, blood-vessels, and nerves, also arranged in a definite fashion. And whereas the masses of metal composing the steam engine would be useless without the intervention of heat produced by some substance, such as coal or coke, and acting through the medium of steam produced by the action of heat on water, so the mechanism of the human body would be altogether useless without the food which we daily consume. Food stands in much the same relation to the human body as fuel does to the steam engine.

But the food of human beings is destined to fulfil other ends besides those implied by the fuel of the steam engine. The latter, after being constructed, daily wastes. Every day it becomes worse; for each stroke of its piston, to say nothing of the motion of its other parts, implies a waste of the piston itself, and of the cylinder in which it is enclosed, and in which it works. Now, when these get out of order, the whole machine has to be stopped, that the engineer may repair the deteriorated portions; but this is impossible in the animal frame without death ensuing. So that the human body is to be looked upon as an engine constantly working, constantly wasting, and constantly repairing its own deficiencies. But, just as the coal which is used to drive the steam engine would be useless for the repair of the brass or iron of which the engine is composed, so would that kind of food which is most useful in supplying the means of motion in the human body be useless for repairing the waste of its tissues.

From this we are led to conceive that human food must consist of more than one kind of material, and so it does. If we take the staple of life as consisting of bread and meat, we find there the necessary substances: for bread, especially white bread, consists chiefly of starch, which may be likened to the coal of the steam engine; whilst meat consists of two portions, the fat and the lean, of which the former goes to aid the starch in propelling the machine, the latter going to repair the waste entailed by the action of the two former. Now how should we set about finding out how much work a steam engine had done in a given time? Not surely by estimating the infinitely small amount of refuse produced by the waste of the iron and brass, but rather by the amount of coal consumed. So in the human body, the work is to be measured by the starch and fat used up, or rather, by the products of these, not by the waste of the muscles [or of the meat in a changed form]. Nevertheless, this error was for a long time made in the case of man, and has only recently been exploded.

Now, as to the different kinds of motion observed in man or other animals, certain of these are common to all kinds of bodies, animal and vegetable, as well as mineral. Of such kinds are the motion implied by chemical change, by heat, and the more marked phenomena of gravitation; but, besides these, there are certain partly physical, partly vital phenomena, such as result from the commingling of oil and water, especially if the latter contain a substance like the white of egg. These movements were first observed by a well-known and distinguished botanist of this country, named Robert Brown, whence the movements are sometimes spoken of as the Brunonian, or, on account of the small size of the bodies concerned, molecular movements.

If we make the acquaintance of some of the lowest forms of animals and vegetables, we find ourselves on a kind of neutral ground, the inhabitants of which might belong to either kingdom, and to which of these they do really appertain it is not easy to say. Many of these lowly forms of animals and plants consist of a kind of jelly-like material, and apparently of nothing else. They have no organs of sense, no organs of digestion even, nor of circulation. Still these little structureless particles have the power of motion, and even of destroying beings much higher than themselves in the scale of animal life. From one of these living masses of jelly, called an *amœba,* this kind of motion, by the protrusion of certain portions of the mass in any given direction, ultimately followed by the whole, has been termed *amœboid.* Still, this variety of motion, not depending upon gravitation, but on the vital action of the living being, necessitates chemical change, and consequently food. It is, indeed, seen even in man, in whose veins, and constituting a portion of his blood, flow certain small rounded and colourless bodies called white blood corpuscles, which frequently exhibit similar changes; often also particles of the same kind in other parts of the body do the same thing.

Mounting to a somewhat higher stage in animal life, we encounter a number of beings furnished with little fringe-like processes, which they can keep in constant motion. These fringe-like processes are termed *cilia,* and their motion is called *ciliary;* it may be used to illustrate a point to which we shall again have occasion to refer. The minute beings furnished with cilia are not unfrequently fixed to one spot, without the power of changing their place of abode. In these beings the cilia are useful for setting up currents in the water by which they are surrounded, by which currents particles of food may be driven to the creatures which are deprived of the means of going in search of it. But in others, which are free, the motion of their cilia in the surrounding water resembles in its effects those of the screw of a steamer, for thereby the little beings are rapidly propelled from one point to another. Perfectly similar are the effects of a steamer's screw, which, the steamer being firmly fixed, would only be able to set up currents in the water; but which, when the vessel is free from the shore, drives it rapidly along. This same kind of motion is also observed in certain parts of the human body, notably in the air passages, which are lined by these little bodies constantly waving about, and tending to drive any wandering particle which may have found its way into the lung back to the outer air.

Still, all these kinds of motion, as seen in the animal frame, sink into insignifigance when compared with that induced by the special apparatus prepared for the purpose, and which we term the muscles; that is to say, the red fleshy parts of an animal. It is with this kind of motion we have mostly to deal, and this apparatus we must carefully describe. There are, then, two kinds of muscles: one set more or less completely under the control of the will, the other more or less completely beyond this; the one kind is seen to most perfection in the powerful muscles of the arm and leg, the other in such an organ as the churning apparatus of the stomach. It is with the former we now must deal, and it will be enough, in giving an idea of its structure, to recall to the recollection of every one how a piece of meat boiled for a long time tends to become stringy. These strings are the so-called muscular fibres, which are themselves, in turn, made up of smaller and finer threads.

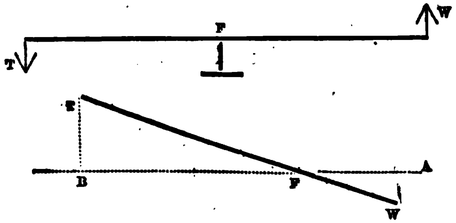
Then, again, each muscle has a beginning and an end, or, as they are technically termed, an *origin* and an *insertion*. Most frequently both of these are connected with bones, the one end with one bone, the other with another; but sometimes this is not so, as in the case of the muscles which move the eyeball, one end of which is attached to bone, the other to the soft structures of the eye. But often the points to be connected are too far distant to be united altogether by muscular structure, and then, just as when a barge has to be dragged along by horses, a rope is used to transmit the power from the horse to the barge, so in the human body certain strong unyielding cords are employed to transmit it from the muscle to the bone; these we call *tendons*. Not unfrequently a muscle has a tendon of origin as well as a tendon of insertion; but it must be distinctly understood, that these are cords merely, which serve to transmit force from one point to another, and have nothing to do with the origin of the force, which depends on the shortening of the red muscular fibres, a property which is innate in them, and which is characteristic of them. When we examine all the muscles of the body (which number upwards of 1,000), especially those of the limbs, we shall find that the one extremity of the majority is directed towards the centre of the body, the other towards the end of the limb, and it is the former which is most frequently termed the origin of the muscle.

If now we trace a muscle and its tendon from its origin to its insertion, we shall most probably find that it passes over a spot where two bones come together. This we term a *joint*, the bones being united in two ways, either so that the one can move upon the other, or so that both are immovable. It is with the former class we have chiefly to deal; and for our purpose we may assume that these joints are of two kinds, either ball-and-socket joints, admitting movement in every direction, as in the case of the shoulder joint and hip joint, or hinge-like joints, such as those of the elbow and knee, where the motions are more limited in their character, and are almost restricted to one direction. For the construction of these joints two things are necessary—smooth surfaces of bone, rendered still more smooth by a layer of cartilage or gristle, the one surface corresponding to and fitting into the other, and strong bands or ligaments extending from the one bone to the other, so as to keep everything firmly in its place, and admit of only a limited degree of motion.

Having explained the machinery, so to speak, of the human engine; having shown it to consist of certain self-contracting muscles, the pistons as well as the boilers of the machine; of tendons, its connecting rods or belts; of joints, the grooves in which the rigid bones move and work; we must fall back on certain elementary principles in order to explain fully the working of this wonderful mechanism. In every solid body there is a point which is termed its *centre of gravity*, which being supported, the whole body will be so; and this in a solid corresponds to the point where certain lines cut each other. In the human body it will not be more to one side than another, and will correspond with a plumb-line dropped from the head when the individual is standing upright. So, again, it will be at those points in this line where the weights of the upper and of the lower half counterbalance each other. Finally, at the point where these two intersect each other, and encounter a third line corresponding with that in which the right side of the body balances the left, is the centre of gravity. In the human being this centre is situated low down between the two haunch bones, but it varies with every movement of the body.

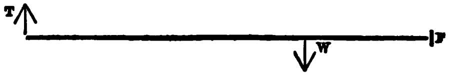
Of all mechanical powers, again, the simplest are those known as levers, of which there are three varieties. A lever consists of a rigid or unbending bar or rod, whereby a force is transmitted from one point to another, sometimes gaining power, sometimes losing it, as in the following examples. Lever No. 1 consists of a rigid rod, movable upwards and downwards only, on a given point, which is called a *fulcrum.* At the one extremity of the rod a certain power is exerted, at the other is the weight to be raised, or the body to be influenced.

1.



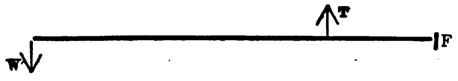
Now, when the fulcrum, F, is near the weight, W, the power, T, will have the advantage of the long arm of the lever; but, on the other hand, will have a longer distance, T B, to travel through before bringing W to a certain level, B A. On the other hand, were the fulcrum, F, nearer T than W, there would be a loss of power, but a gain in the distance to be travelled through; which, as it must be done in the same time by both arms, is technically known as a *loss of velocity.* On the other hand, were F equally distant from T and W, both would be in exactly the same predicament; there would be neither gain nor loss in power or velocity, but the force would be transmitted unimpaired from T to W, and the velocity with which these would pass through a given distance would be the same. This is the condition in that useful example of a lever, the common balance for weighing sugar and tea and such like commodities, where the pound weight is the power, the knife-edge by which the balance is suspended is the fulcrum, and the substance weighed is the weight to be raised.

2.



In lever No. 2 we have the power at one end, the fulcrum at the other, and the weight between the two; so that it is evident that in this there must always be a gain of power, as the weight, being nearer F than T, will rest more upon that extremity of the lever, whilst there is a loss of velocity, T having to travel through a greater distance in a given time than W has.

3.



In lever No. 3 the very reverse is the case; for in this instance, the weight, W, is at one end, the fulcrum, F, being at the other, whilst the power, T, is between the two; so that, in this case, there is invariably loss of power and gain in velocity. As common illustrations of these forms of levers, we might take of No. 1, the act of stirring the fire with a poker; here the coals are the weight to be raised, the bars of the grate are the fulcrum, and the power is the hand applied to the end of the poker. So, of No. 2, a man pushing a wheelbarrow is a good example; here, the fulcrum consists of the wheel resting on the ground, the weight lies in the barrow, and the force is applied through the medium of the handles beyond it. Of the third form of lever we might take an example from a man in the act of dragging from the wall a ladder leaning against it; this he does by pulling one of the steps on a level with his shoulder (the power), and pushing his foot against the lowest step of the ladder (the fulcrum), and so raising the ladder (the weight) straight up in the air.

When we come to examine the human body, we find examples of all these forms of levers, although not in the same abundance. Thus of the first, where the fulcrum lies between the power and the weight, we may take the common illustration of a man who has fallen asleep in his chair, when insensibly his head falls forward on his chest. Suddenly he awakes, and throws up his head, thus calling into play a lever of the kind described. For here, we have the head hanging forward as the weight, the fulcrum is the back-bone on which the head rests, whilst the power is the muscles fixed to the back of the head and to the back of the chest. The same kind of action is seen in a horse throwing up his head after drinking, and so on; but levers of this kind are not very numerous in the human body.

Lever No. 2 is exemplified in that kind of action which is implied by a man standing on tiptoe, for in this case the whole weight of the body, which ordinarily rests on the arch of the foot, is thrown forward, so as to rest on the toes, by means of the strong muscles in the calf of the leg contracting, and dragging up the heel. The toes are the fulcrum; the body resting on the arch of the foot is the weight; and the tendon of Achilles connecting the great muscles of the calf with the heel represents the power.

Neither is this kind of lever common in the human body, which, for the most part, chiefly affords illustrations of the *third* kind of lever, where the weight is at one end, the power in the middle, and the fulcrum at the other end. To take a common example: in bending the forearm and hand on the arm, so as to bring the hand on a level with the shoulder, a strong muscle, called the *biceps*, is brought into play. This is the power, and it acts on the forearm just in front of the elbow joint, which is the fulcrum, whilst the hand and anything contained in it represent the weight to be raised. Now, the reason this kind of lever is so much more common in the human frame than any of the others is simple enough. There is, in the first place, the fact that it admits of much greater symmetry, but, from our present point of view, this is of no consequence; the second is, that, in the animal frame, the power which may be applied is practically unlimited, so that a gain of velocity is of much greater importance than a loss of power, for a muscle can easily be made large enough to insure strength as well as swiftness.

Still, in the human body, the means of employing force are identical with those seen in the steam engine, for there also, we have to deal with a series of levers. The up-and-down motion of the piston is communicated, by means of a crank, to a horizontal beam, which bears one or more toothed wheels, or some similar means of carrying power from one spot to another. But these toothed wheels are only levers, where the axle is at once fulcrum and power, a combination which implies the greatest possible velocity with the greatest expenditure of power. The wheel which is driven by the one attached to this axle represents the weight.

When further we come to consider these mechanical forces as applied in the human body, we have to notice that, in very many instances, the tendon of a muscle is inserted obliquely into its bone; this implies an additional waste of force, for the nearer the perpendicular a force is brought to act on the lever, the greater is its effect. But, just as outside the body we find the direction of a force changed by means of a pulley, so we find the same thing accomplished in the body, when the tendon of a muscle is bound down by a sheath or a ligament, thereby effecting the change of direction with very little loss of power.

In all muscular actions taking place in the human being, the mechanical principles we have laid down are observed; but they are probably best illustrated by the various forms of progression, that is, moving from one place to another, employed by the human being. This leads us to consider another point in mechanics connected with what is known as the *base of support*, as applied to the centre of gravity. Every one knows how much more difficult it is to keep upright a tall, thin body, than a broad and flat one; or, to take an extreme instance, to keep a spinning top upright on its point than on its head. This is because the base of support is narrow in the one case, broad in the other. In walking at sea a man strives to keep his feet apart, because the line from the centre of gravity naturally falls between his feet, and the farther they are apart the greater is his basis of support; and this habit gives to sailors their peculiar and, to landsmen, awkward-looking gait. There is an old saying, that cats always fall on their feet; the reason is, that the line from their centre of gravity falls downwards to the ground between their four limbs, and being extremely active they can always manage to keep it there. So babies, when beginning to move about, crawl before they walk, the centre of gravity being so much more easily kept within the base of support in the one case than in the other. As soon as the centre of gravity is disturbed, so that a line drawn from it, perpendicular to the surface of the earth, falls outside the base of support, a movement must be made, or the individual will fall down. This explains the old trick of asking a man to walk up to a wall, to place one foot close to it, and parallel with it, and then, asking him to raise the other, he finds he cannot do so without falling, simply because his centre of gravity would fall without the narrow base of support afforded by the one foot.

Now let us consider the means by which a man may move from one place to another, thereby expending force in causing the contraction of certain muscles, these muscles acting on certain bony levers, whereby the body is moved. This leads us to consider the ordinary attitude of man in walking, the erect posture characteristic of the human race. The maintenance of this posture is not a merely passive act, for it requires the constant action of a certain number of muscles, which act in opposite ways, and so keep the human being upright. The first thing to be noted is the way in which the body is supported on the foot. The foot itself consists of an arch, the base of which is more extended in front than behind, and the whole weight of the body is made to fall on this arch by means of a variety of joints. These joints further enable the foot to be applied to rough and uneven surfaces, so that the flat portion of the foot may be adapted to these without inconvenience. The foot is connected with the leg by the ankle joint, before and behind which pass down tendons of muscles situated in the leg and directed to the toes, so that when both contract equally, the leg is held firmly on the foot or the foot on the leg. The same arrangement is seen at the knee and at the hip; and in each instance we have a series of muscles on one side which may be made to antagonize those on the other, and those in front to oppose those behind: by the simultaneous action of all these muscles the limb is held fast, and the upright position is maintained. The one set of muscles, which keep the limb straight, are called *extensors,* those which bend the limbs are called *flexors.* It will thus be seen that the maintenance of the erect posture is by no means a passive effect, but the result of constant muscular contraction; so that when a man is stunned, or in any other way loses the command of his muscles, the first consequence is his tumbling down. The same names are applied to the muscles of the arm, but they are only called into play at intervals, and are not so constantly in action as the muscles of the lower extremities.

Connected with this subject is a venerable joke current among students of medicine, to the effect that, once on a time, a rude examiner asked a student who was being examined by him, "Now, sir, what muscles should I call into play were I to kick you down stairs?" To which the dutiful reply was, "The extensors and flexors of my arm, sir; for I should immediately knock you down." In this same action of kicking, exactly the same muscles are called into play as in keeping the body upright, but they act in a different way. When a man stands erect, his foot planted firmly on the ground, any contraction of the muscles of the foot would only result in raising the body as on tip-toe; but should the limb be raised off the ground by bending the knee, then the muscles can act freely, and the foot can be moved in any direction: in the one case, the foot is the part most firmly fixed—in the other, the body is so.

Now, in walking, the first thing done is to throw the weight of the body on to one limb so as to free the other, which is then bent and flung forward until it reaches the ground; the centre of gravity advancing so as to fall between the two limbs, and beyond the original basis of support. When the foremost foot has been planted on the ground, the hinder one is found to be raised at the heel, so as to rest on the toes only, if the forward step has been a long one; but this is not the case in ordinary walking. The muscles are now powerfully called into play so as to act upon the leg and foot; but this being resisted by the toes planted against the ground, the opposite effect takes place, that is to say, the body, being more movable than the foot, is thrust forward. The hinder foot is carried with the body until advanced to a level or in front of the other, the centre of gravity being at the same time carried forward with the body. Running is effected in the same way, but at a quicker rate, and the centre of gravity is generally kept quite in advance of the base of support; so that, if the feet are not moved quickly enough, or are interrupted in their progress, the individual is certain to fall.

It will thus be seen that the movements of the human body are effected in accordance with the same laws as regulate movement in the inanimate world. Of course we do not now speak of the intelligence displayed in these movements—that is a totally different thing; we only deal with the mechanics of motion as seen in, and illustrated by, the human body. In another chapter we shall speak of the adaptation of these principles to actual life in the practical forms of gymnastics and training.

XX.

THE INFLUENCE OF OCCUPATION ON HEALTH.

In previous chapters we have explained the structure and function of various organs in health and in disease; it is now our intention to show that many of the diseases to which our bodies are subject, arise from simple and often easily remediable accidents of our daily life. A very close relation exists between health and occupation; and the more widely a knowledge of the principles of sanitary science is diffused, the more certainly will the health and happiness of our working population be secured. England cannot, indeed, hope to maintain her pre-eminence as a manufacturing country, unless the health and vigour of her artisans is preserved; and the prospects of the "working man" would be more surely advanced by improvements in his sanitary and social condition, than by an increase of his political power. It is always the feeble and unhealthy who are the most dissatisfied with their lot, and clamorous for the reform millennium; the healthy body and satisfied mind exist together, and a man who has health to enable him to overcome obstacles and make his way in the world, is not likely to be very particular about the roughness of the road.

The influence of occupation on the health is not a subject for the consideration of a single class; for what overwork of body does for those who earn their daily bread in "the sweat of their brow," overstrain of mind effects for those who live by their brains. There have been many instances from the ranks of literature, science, and art, of men whose lives have been sacrificed by too intense devotion to their pursuits. Mendelssohn, who concentrated more brain-work within his short life than has sufficed for many whose years have extended to ten decades, died of paralysis at thirty-eight; his premature end most surely hastened by the perpetual unrest in which he spent his every day.

Our subject readily divides itself into two sections, viz., (*a*) influences general and indirect; (*b*) influences special and direct.

Amongst the former we refer to conditions of defective ventilation, overcrowding, long hours, etc.; and under the latter head we shall classify the injurious influences of particular trades.

The packing together of numbers of human beings in a confined room, tends at once to impair the purity of the air; for its vivifying principle, oxygen, is replaced by that most injurious gas, carbonic acid. It is a primary natural law, that man needs an abundance of pure air to support his healthy existence.

> "A breath of unadult'rate air,
> The glimpse of a green pasture, how they cheer
> The citizen, and brace his languid frame!"

How imperfectly this requirement is supplied in large manufactories, and what a powerful source of mischief is at work in such places, may be indicated by the following facts. In 100,000 parts of pure air, there are rarely found more than 30 parts of carbonic acid: in rooms in towns, freely ventilated, the proportion rises to 80 parts in the same volume, while in ill-ventilated rooms and workshops there have been found from 100 to 700 parts, or twenty times nature's allowance. The working classes are exposed to no more fruitful cause of disease than this excess of carbonic acid in the air which surrounds them. When a high percentage of carbonic acid prevails, the circulation of the breathers is generally observed to become enfeebled, the frequency of respiration to increase, and nervous power to fail. Much of the consumption and scrofula of town populations is due to an atmosphere overcharged with this gas. Nothing affects its power for ill so much as an elevated temperature. "Thus even 1 per cent. of carbonic acid may be endured at a temperature under 50° Fahrenheit, which at 70° or 80° would be absolutely intolerable." On entering a close room in which a number of persons have been employed for many hours, the atmosphere seems quite unbearable, and we gasp for an open window; while the workpeople, accustomed to the vitiated atmosphere, seem to breathe with ease, and say they do not feel any inconvenience. Is the closeness innocuous because it is not felt? By no means. Acclimatisation is dearly bought. By the gradual depression of all the functions, less oxygen is absorbed, and the vitiated air then suffices for an enfeebled organism, just as it would for the respiration of a cold-blooded animal. This kind of vital depression, when frequently experienced, is destructive to the elasticity and vigour of those exposed to it. In such an atmosphere, rapid and efficient work, to say nothing of comfort and happiness, is out of the question. It is gratifying to find from the last published reports of the Factory Inspectors, that very decided physical improvement has been effected by the factory regulation laws, and as a natural consequence "a wide-spread and almost universal improvement in tone both of the employer and employed has been noticed." Attention to the laws of health is thus seen to secure an immediate and permanent reward.

Long hours are not now, happily, so crying an evil as formerly, for the legislation of 1867 has placed reasonable limits on the time during which employers can keep their hands at work. There is even now, however, ample evidence of the prevalence of this evil, especially as it affects the young. In the east end of London, where it appears to be practically impossible to enforce the wholesome regulations of the Workshop Act, in consequence of the pauperism of the population, many hundreds of young children are employed from eight to ten hours a day in light handicrafts, such as the making of lucifer-match and other small boxes. Lord Shaftesbury's "Children's Employment Commission of 1861" brought to light many glaring instances of overworked children in the hosiery trades of Leicester and Derby, the straw-plaiting trade of Luton and Dunstable, the iron trades of South Staffordshire, and many others. It was invariably found that the most exacting taskmasters were the children's own parents, and recent experience in London confirms this fact. What wonder that the mortality should be excessive in districts where children have been kept hard at work in a temperature varying from 106° to 120° for six-and-thirty hours without going to bed, as in the glass works of Yorkshire, or where infants of but six years are pent up for fifteen hours out of the twenty-four in small overcrowded rooms, as in the lace schools of Nottinghamshire? * Surely no more unfavourable conditions for the healthy development of mind and muscle could be imagined.

The restriction of the hours of labour in factories is not an unmixed good. In busy seasons, the necessity for rapid completion of orders is at times so great that home work is encouraged, and there performed perhaps in close rooms under even more unfavourable conditions than exist in the factory. It is not, of course, possible to carry about engines and machinery, but in many branches of trade "finishing work" may be done at home, and the limitation-of-time enactments are thus rendered worse than useless. In these "season trades," as they are termed, in which for several months in the year there is nothing to do, and then for a few months more than can be readily accomplished, it may perhaps be found that some slight modification of the law giving permission for a few extra work-hours per week during the summer months, may be found sufficient to meet their requirements. It is satisfactory to learn from the recent reports, that those employers who have acted up to the spirit of the "Workshop Regulation Act" have found that the

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* See Reports of above Commission.

increased energy and activity of the hands, when working under improved conditions in airy rooms, leads to the production of as much work in ten hours and a half as formerly required twelve or thirteen hours. In the presence of this fact, it is disappointing to read that the lace and straw-plait schools (being neither factories nor workshops) escape the operation of this Act, and many of the bonnet makers,* who consider themselves "young ladies," resist the interference of any law which classifies them with "factory workers."

Legislative enactments for the remedy of these evils exist already, which, if fully carried out, would accomplish much. A sufficient cubic space must be allowed to every factory hand, as it is to lunatics and paupers; and regard must be had no less to the quality than the quantity of the air supplied.

Plainly, to manufacture perfectly pure air by Act of Parliament and deliver it on the premises, is impossible: we must, therefore, do what we can to keep it wholesome, by devoting strict attention to ventilation, by the adoption of disinfectants for drains and sewers, so as to kill or render innocuous all organic impurities, and by the preservation of open spaces in and near our great centres of industry. The ventilation of mines is under legislative regulation, and with the most beneficial results, many lives being thus saved annually. The ventilation of lodging-houses is also subjected to police supervision in the interests of their casual occupants. Surely the thousands who spend their lives in our workshops and manufactories have even a greater claim on the care of the State.

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* Although "there are no bonnets made now-a-days, straw may be worn in a thousand fascinating shapes," and the pressure put upon the producers is often temporarily so great as to lead to most distressing breaches of sanitary laws.—*R. Baker, Esq.*, "*Report on Factories*," *to Oct.*, 1868.

Much also might be done by the working classes themselves, by the cultivation of habits of personal cleanliness. The fact must not be disguised, that a most baneful consequence of overcrowding is the vitiation of the air by the emanations from the bodies of diseased or uncleansed persons. French scientific investigation has disclosed the unpleasant fact that skin dirt, composed of perspiration, oily matter, and dust, contains myriads of microscopic existences, both vegetable and animal. These cutaneous emanations are dissipated in and affect the air; add to these the pulmonary exhalations of consumptive and scrofulous persons, which are believed by some to be vehicles of contagion, and some idea may be formed of the risk to health incurred by those whose days are spent in an atmosphere so highly charged with organic impurities. "The greater the aggregation of unwashed human masses, the more horrible must be the resulting atmospheric impurity." (Rumsey.)

In calculating the amount of evil arising from general causes, such as those now under consideration, the fact should not be overlooked, that although there may be no fatal disease, a condition of what has been called negative health is sure to be engendered, and the majority of the workers become debilitated, until life itself becomes a misery.

It is impossible to over-estimate the advantages which accrue to those who can mitigate the effects of the poison inhaled during the day by a residence where—

> " 'Tis rural: trees are to be seen
> From every window, and the fields are green;"

and it should be a matter for general congratulation that the building of dwellings for the labouring classes in the suburbs, and cheap trains for their accommodation have brought this immense privilege within the reach of many who could not a few years ago have obtained it.

The working classes hold a remedy against long hours in their own hands;* but it is surprising to notice how slow they are to avail themselves of it. Indeed, they may be said in one respect to be consenting parties to the prevalence of this evil; for the adults are in most instances not slow to seize the opportunity of earning "overtime," and parents will go so far as to put pressure upon managers to employ children of tender years, and do not scruple to misstate the age of the little ones, so that they may not be brought within the clauses of the Factory Acts. Let operatives work more quickly while they are at work, that they may have time for rest or recreation after the day's work is over; for by means such as these they are more surely promoting their best interests than by falling in with the arbitrary regulations of trades' unions, as that, for instance, which enjoins that a man must only use one hand in laying a brick. The lower orders of the working classes might well take a lesson from the change which has passed over the habits of City men of business. A few years ago the ordinary working hours were from 8 a.m. to 8 p.m.; whereas now 10 to 5 is the rule; work which formerly occupied ten to twelve hours being now accomplished in half that time. But we can scarcely expect that any real improvement in the particulars we have mentioned will result until the elementary laws of health are taught in our schools, and the working population have learned how much the maintenance of the sound mind in the sound body, "the only fund to which they must look for subsistence through life," depends on themselves. May we not hope that the English workman (instead of looking for assistance from the Legislature, or from benevolent societies) will determine to secure for himself those advantages which his own vigour and energy so well qualify him to attain?

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* We hope we may not be understood by this expression tacitly to advocate "strikes," for any such attempted remedy almost always proves a worse evil than the disease.

The general or indirect influences which affect the health of the operative class, have hitherto engaged our attention. We will now refer to those directly attributable to certain callings. Such a large proportion of the ailments and diseases of this section of the population have an intimate relation to their occupation, that it is difficult to deal with the subject within the limits of a single chapter. As the enumeration of every trade to the pursuit of which special evil may be traced would probably prove tedious, we present in a tabular form on page 190, a few of the more prominent instances.

A few additional particulars in explanation of this summary may be of interest. The destructive influence of the steel-grinding trades of the Sheffield district was not generally known until the fork-grinders (who work on dry stones) drew up a description of the pernicious effects of their calling; in which they declared that the average age of a fork-grinder did not exceed thirty years; that the men early contracted the "grinder's complaint," an asthmatic cough ending in consumption; that "life was a burden, and the frames of the poor sufferers wasted away, by a repetition of slow tortures." This was no over-statement of the case. A poet of their own town has graphically described the perils incident to this occupation, and, it must be added, has no less truly depicted the prevailing character of many of its victims.

> "There draws the grinder his laborious breath;
> There, coughing, at his deadly trade he bends;
> Born to die young, he fears not man nor death,
> Scorning the future, what he earns he spends: . . .
> Yet Abraham and Elliot * both, in vain,
> Bid science on his cheek prolong the bloom:
> He will not live! he seems in haste to gain
> The undisturbed asylum of the tomb,
> And, old at two-and-thirty, meet his doom!"

Flour, and more particularly dried "corn flour," is almost as injurious as metallic dust, affecting the constitution in much the same way. Bakers and millers are a short-lived class of men, seldom attaining more than forty years. "Shoddy grinders," boys employed in paper manufactories to sort, pick, and tear up old rags, suffer from a peculiar form of bronchitis caused

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* The inventors of the Grinder's Preservative, which the grinders will not use.

Occupation.	Average Hours.	Special Evil.	Remedial Measures.
Copper and zinc workers . . .	8 or 9	Inhalation of sulphuric acid, and coke fumes	Closed fireplaces, good flues, and thorough ventilation
Knife and fork grinders, sand-paper makers, glass grinders, &c.	10	Lung disease from irritant effects of metallic particles inhaled	Magnetised wire, or other respirators.
Millers and bakers	10	Lung disease from inhalation of flour dust	Revolving fans and respirators
Stonemasons	10	Lung disease from chips and dust of marble, stone, etc.	Natural respirators, viz., moustache; or artificial ditto, as gauze or handkerchief.
Cocoa-nut matting makers and weavers. "Shoddy grinders"	. . .	Bronchial affections from inhalation of dust	Gauze respirators.
Tailors and shoemakers . . .	12 to 20	Confined posture in close atmosphere	Adoption of sewing machines, change of position, and ventilated work rooms.
Milliners	Uncertain	Close rooms, long hours, and night-work	Shorter hours, and airy working and sleeping rooms.
Sewing-machine hands. . . .	10	Stooping posture in close rooms	Ditto.
Warehousemen	8 to 10	Dusty and straining work, lifting heavy goods beyond strength	Care not to overtax physical powers.
Telegraph clerks	12	Close concentration of mind in confined atmosphere	Working in relays.

Occupation.	Average Hours.	Special Evil.	Remedial Suggestions.
Law stationers and commercial clerks	Very irregular	Compression of chest, producing malformation, and confining free action of heart and lungs, writers' cramp, or scribe palsy	A back to the high stool, light and flexible penholders.
Lucifer-match makers	. . .	Contact with phosphorus, producing jaw disease, "necrosis"	The use of amorphous phosphorus.
Artificial flower and green paper makers	. . .	Poisoning by arsenite of copper, causing loss of hair, loss of appetite, nausea, eruptions on the face, etc., etc.	The use of non-arsenical pigments.
Looking-glass silverers and barometer makers. "Water gilders"	. . .	Mercurial poisoning from absorption of mercury into the system	Careful washing, and the avoidance of direct contact with the mercury. Electro-gilding.
Printers and compositors . . .	16 to 18	Close atmosphere contaminated by constant gas-burning	Ventilation.
Type-founders, plumbers, and painters	10 to 12	Paralysis, wrist palsy, muscular wasting, caused by antimony and lead-poisoning	Machinery for mixing paints, frequent handwashing, especially before meals.
Engine-drivers and stokers . .	Irregular	Exposure to cold and wet, and heat of fire	Covered engines, as in Russia, America, etc.

by their dusty work, and chaffcutters and many others are similarly affected. The principal predisposing cause of the ailments of tailors and shoemakers is the adherence of these trades to the practice which demands that while at the "board" they shall squeeze themselves up into the most ridiculous of postures: which it is obvious must considerably curtail the space allotted to the free action of the vital organs. The adoption of the sewing machine is, however, taking much work out of the hands of the journeymen tailors, a girl being able in a week to attain as great proficiency in sewing or stitching as an apprentice would take two years to achieve with his unassisted needle.

The hard lot of milliners is well known. We mention their case only for the purpose of suggesting that the public who employ them might, by careful foresight, do more than the masters for the alleviation of their misfortunes.

Our readers will hardly have expected to find that sewing machines, so freely spoken of as the remedy for the grievances of overworked seamstresses, may be themselves classed among agents of mischief; but some machines work heavily with an up-and-down movement from the hip, which soon becomes extremely wearing; while others are set in motion by a light heel-and-toe action, which may be long carried on without injury.

Our writing masters must be held responsible for much of the disease which attacks those who spend their lives at the desk, since children are taught to write with their bodies twisted into almost impossible contortions over their copy-books, instead of being allowed to sit in an easy, natural attitude. We can recommend those who have to write much, to adopt Lord Palmerston's plan of standing while they write, or else to sit on a chair with a back to it which may be drawn near the desk, and thus supply a rest for the back.

The arsenical compounds, mercury, lead, and antimony, the special bane of artificial flower makers, meteorological instrument makers, and of plumbers, painters, and printers, are subtle poisons which insinuate themselves into the system, and, as surely as they find an entrance; produce most disastrous results. Arsenic and mercury speedily induce a combination of disorders which end in an early death, whilst lead and antimony deal far less mercifully with their victims. It is the feature of lead-poisoning that all the natural functions are impeded; the removal of effete and injurious matters, which is continually taking place in a healthy person, is checked; and therefore the poison remains and accumulates in the system until circulation and respiration become enfeebled, and death ensues. A painter, when discussing his midday meal, should realise that the lead in the paint on his hands is passing by little and little, *viâ* the bread and cheese, into his stomach, and may become the fruitful parent of many disorders.

A preparation of white lead (sugar of lead, as it is termed, from its sweet taste) has been largely used to whiten straw hats and bonnets. The dust is diffused through the air, and is inhaled and swallowed by the workpeople in such quantities as to be most injurious. Much illness has thus arisen, and several lives have been sacrificed. It has been suggested by a practical chemist, whose attention was drawn to the evil in question, that a paste composed of sulphate of baryta might be employed instead of the lead. This has been found to work well, and is quite innocuous. The white oxide of zinc will on trial be probably found equally fitted for the purpose. We would fain hope that we shall hear no more of lead-poisoning in the straw-plait trades.

These insidious foes are much more readily kept outside the walls, than ejected when they have succeeding in forcing an entrance into the citadel, and the workers in these metals should carefully adopt simple but effectual preventive measures. Too much attention cannot be given to frequent and thorough cleansing, and a very Pharisaic dread of eating with hands unwashed would prove most wholesome.

One or two exceptional cases, which well illustrate our subject, have recently been brought under observation. A man suffering from lead-poisoning came to us, and in reply to our inquiry as to its cause, informed us that he was a clown, and had been using oxide of lead in order to give his complexion the particular hue required by the traditional usages of the stage. White zinc would not have been so dangerous, though probably equally effective. This incident may be a warning to others who seek to improve their appearance by the use of similar means, for clowns are not the only persons who resort to external applications for "beautifying" the complexion.

The men employed in riveting iron ships long suffered from the consequences of inhaling the noxious fumes from the furnaces used for heating the rivets within the ship's hold; fresh air could only be obtained through the hatchways, and the men died. At length a remedy was found; the rivets were heated on deck, and allowed to slide down pipes to the part of the ship where they were required. The products of combustion, so destructive in the above case, make the atmosphere of tunnels and of the Metropolitan Railway oppressive, and prove injurious to the men employed on the under-ground line. This poison is most rife when, in a fit of misplaced economy, an attempt is made to burn impure and smoke-producing coke.

It will have been noticed that most of the occupations to which allusion has been made, have been such as are carried on indoors. The fact that those whose avocations expose them to the inclemencies of the wind and weather are far more healthy and long-lived than those who work under cover, is as remarkable as it is undoubted. When times of depression in trade occur, those whose business has kept them within doors cannot stand exposure to the elements, and are specially unfitted for emigration, however it may be called for by the terrible increase of our pauper population. To transport broken-down factory hands, and expect them to till the soil of our colonies, is plainly a mistake; but the scheme of taking their children to grow up in the open air where food is plentiful, instead of in crowded alleys where meat is at starvation prices, commends itself to all, provided that means are adopted for the proper care and protection of the youthful colonists.

In conclusion, let it ever be borne in mind that whatever may be the specific dangers attaching to particular occupations, there is no disease so deadly as no occupation at all; it is a rust that corrodes, and a canker that corrupts all vital power both of body and mind. The absence of definite purpose in life, and of regulated effort to realise that purpose, is productive of the fatal distemper, of the languid stagnation of ennui, or of the distorted and morbid activities of hypochondriasis, rendering God's gift of life a burden or a torment.

It is never to be forgotten that labour is a law of our being; and even if there be some penalty involved in the difficulties and dangers attaching to labour, still it is at once man's glory and happiness to surmount and overcome them. Lord Stanley has feelingly and eloquently depicted the miseries affecting those who by their worldly position seem exempted and hold themselves exempt from the law of labour, and has commiserated those who consume much and produce nothing; production in proportion to power is the secret of a happy balancing of mind and body.

No one can take even a superficial view of the world in which we live, of the vast and ever unfolding secrets stored within its bosom, and of the marvellous faculties by which man is fitted to discover, develop, and apply those secrets, without feeling that well-regulated labour is happiness; that indolence is death; that "labour" is graven with a pen of inspiration over the field of the universe.

XXI.

TRAINING AND GYMNASTICS.

We have dealt with the theory of motion as applied to the mechanism of the human body, and we have spoken of the application of our principles to one of the simplest forms or modes of animal motion, namely to walking. Nevertheless, although the power of changing its place is one of the great characteristics of an animal, in the case of the human being there are acts much more complex, and which require a more prolonged training than mere locomotion. Many of these movements involve the simultaneous or successive action of various groups of muscles, and each of these groups must be trained to take its appropriate portion of duty. Many of them also require great speed in their performance, others again great force, and sometimes both are necessary; but it may be safely assumed that if such be the case, *i.e.*, if both speed and force are necessary, the stage of training requisite for the due and proper performance of the action will become of necessity more important and more lengthy. Herein lies the difference between the labour of a skilled mechanic and a raw apprentice. But, besides special training for special efforts, it is now-a-days well recognised that, for the human body to attain its greatest beauty and its greatest power, it is necessary to train not one set of muscles, or even several sets, but all in turn, and it is on this account that gymnastics have of late years received the attention they have, not only as a means of physical or bodily education, but also as a method of curing disease. Both of these subjects we shall consider in turn; but we shall first speak of the preparatory process, or that of training.

By all nations in a comparatively rude state of civilisation, feats of strength are highly esteemed; and among those which have attained a higher stage, strength when combined with skill is still valued and respected. Among the ancients, both Greeks and Romans, games of strength and skill were frequent, and even till lately boxing and prize-fighting were favourably received among ourselves. But then, as now, to a candidate for popular favour a prolonged stage of training was necessary before he could hope to attain to eminence; hence there arose a class of trainers for such exercises, as we have now-a-days at our universities in the form of grinders, men who train candidates for mental instead of bodily encounters. Gradually the plan adopted by these men grew into a system, merely from experience, not from any scientific notions, and it is this system we have to examine.

If a man sets about any unusual exertion, say running a race, he will soon become painfully aware of the efforts required to keep up his circulation and his respiration; his heart will thump against his side, and his breath come thick and fast; whereas a man by his side may be going along as quietly and as easily as possible; but then he has been trained. We have shown how scientific mechanical principles may be brought to bear on human movements, how the muscles act on the bones as levers, how the muscles themselves may be likened to a steam engine. But to enable this engine to do its work, fuel is necessary, and this is supplied by the blood; if, therefore, the engine is called upon to move faster than usual, more fuel will be necessary, and the blood will require to be driven more rapidly through its textures. But as the blood soon becomes fouled with the products of its combustion, it requires renewing, and air must be admitted more rapidly into the lungs to carry off the foul gases produced. Hence increased muscular action implies a more rapid circulation of the blood and a more frequent breathing than are ordinarily required. This, then, is the scientific basis on which we have to proceed.

Trainers of the olden times supposed they had to contend against a fearful and concealed enemy which they called *inward fat;* and it was to dislodge this formidable antagonist, their efforts were chiefly directed. It was this, they said, which impeded respiration and circulation, which made a man puff and blow, and made his heart kick against his side. So far, no doubt, they were right; for fat will accumulate internally as well as outwardly, and especially the heart may so become affected, although this is not the dread foe to human life about which medical men talk; for there is another form of fatty heart, where the very texture of the muscle of the heart is turned into fat, and there is so little hope of training a man with such a heart to become an athlete, that the quieter he keeps himself the better for his life. Nevertheless, fat may accumulate, and so render the action of the heart less effective; but this is not the true explanation of the difficulty of breathing experienced by men suddenly called to unwonted exertions, for it occurs equally to fat men and to lean.

Every one is familiar with the fact that a man's bodily conformation materially depends on his employment; hence the strong sledge-hammer arm of the blacksmith, the horny hand of the shoemaker, and so of a variety of other occupations. For the human body is so constituted, that if any part is called upon for unusual exertion, this exertion implies more rapid change of the blood in its parts, as well as a more liberal supply of that all-necessary fluid, which in its turn insures increased growth and bulk of the part. Thus, therefore, in a healthy individual increased exertion implies increased bulk and increased capacity for exertion. This is the basis of the training system, and the basis applies equally to external and internal organs. If any of a man's muscles be suddenly and unexpectedly called upon to perform some duty to which they are not accustomed, whether raising a heavy weight from the ground, throwing it from one spot to another, running or leaping—in short, any unwonted exertion—they will fail to perform it as satisfactorily as those which have been trained to their work. Further, the exertion will leave behind an uncomfortable soreness, which may last a day or two, indicating that the parts have been strained in performing this novel duty; but should the exertion be persevered in, the sense of soreness will become less and less till it entirely disappears; the exertion required to perform the act will also be less and less, for the muscles will be strengthened by each new exertion until finally they will perform their duty easily and satisfactorily.

But what applies to the outer parts of the body also applies to the more internal; for the heart, whereby the blood is circulated, is a hollow muscle, and the principal forces whereby respiration is effected are also muscular. Now, a man's heart and his respiratory muscles may be good enough for ordinary purposes, he may have no difficulty of breathing nor any inconvenience of circulation, and yet if any extraordinary exertion is required, both heart and lungs may fail to do their duty in their usual quiet and imperceptible fashion. The cause of this will be readily intelligible from what we have already said—both the circulatory and the respiratory apparatus require training if they are to be called upon for any special efforts, just as with the more external muscles of the body.

A proper system of training must accordingly be one which provides for the due exercise of all the muscles, voluntary, respiratory, and circulatory; but it should also imply a diet best suited for the development of the muscles, that is, the formation of hard flesh, not of fat, for fat is not only useless, but injurious, from a trainer's point of view. Most of our readers will remember the general interest which was excited by Mr. Banting, when he published his pamphlet on corpulence. In this Mr. Banting pointed out the proper means to be adopted for getting rid of superfluous flesh, as it is euphoniously termed—in reality, of fat; he showed that a diet consisting almost entirely of meat, or of substances containing little starch or fat, would, in course of time, reduce any one to the desired condition. This mode of procedure was enthusiastically adopted by a multitude of followers, some of whom indulged in it—if we may use the expression—or at all events carried it, so far as to make themselves seriously ill. Now, in the olden time something of the same system was adopted; men were fed on half-raw beef-steaks (biftecks sanglants, as the horrified French restaurateurs call them) with a small proportion of stale bread and certain vegetables. No beer or spirits of any kind were allowed. No doubt in the main this process was correct, for the meat would be the best thing to nourish the muscles, that is to say, to supply the waste of the engine; but it is not the best thing for fuel, for some other article of diet should be used as well as bread and meat, otherwise the system is sure to suffer.

Our readers may have seen the statement in the newspapers about the period of the University boat race, last year especially, that the Cambridge crew was trained *too fine*. This simply means that they had had too much work to do, and that their limited diet had told upon them, and made them weaker than they otherwise would have been. Many of these men while training suffer from boils, almost invariably an indication of a low state of bodily health, and not unfrequently more serious results supervene. Navvies, again, are a class of men who work harder than most others, and their diet is often principally made up of bread, bacon, and beer; now this diet, although more liberal in several respects than that allowed by trainers, is still too limited; for not unfrequently these men suffer from scurvy almost identical in its character with that which afflicts seamen on long voyages when their ships are badly provisioned. It is further well known that a man cannot be kept in a high state of training for any length of time; he may be brought to perfection as far as muscular strength is concerned, but he cannot be kept there except his diet be altered; if not, he trains *too fine*. Now-a-days, however, trainers are becoming wiser. Mr. Maclaren, for instance, the well-known Oxford trainer, has published a work, which ought to be read by any one who sets about fitting himself for any great bodily exertion; he has pointed out the errors of the older systems, and shown that with the new better results may be attained. He boldly attacks the ancient beliefs as to inward fat and such-like superstitions, and founds his system on a strictly physiological groundwork. The first and most important consequence of this change in doctrine is a change of diet, which, under the new system, is much more liberal than of old.

Diet no doubt constitutes an important portion of any system of training; by it alone, as we have seen, bodily changes of considerable importance may be effected, but by it alone we cannot develop our muscles, or give the frame unusual power and endurance. For this, exercise is necessary. As we have again and again said, increased action implies increased waste, but also more speedy growth as well as greater development, whence its value in a system of training. But exercise to do good should be systematised, and that now-a-days has been done, the system constituting what is called Gymnastics. We have said a *system*, for gymnastics, except undertaken systematically, are useless. Further, we have pointed out that gymnastics should be employed for two special objects; the one as a means of educating the body, the other for curing it in certain forms of disease. Then, again, according to the end in view, the character of the exercises should vary, and accordingly we have two systems to deal with, known respectively as *light* and *heavy* gymnastics.

Exercise, although the fact is too often overlooked, is really one of the necessaries of life. Man has been condemned to earn his bread by the sweat of his brow, but in return his labour has been blessed to him, for thereby his body is strengthened, his happiness increased, and his life prolonged. There are two great motives or inducements to exertion; these are, the necessity for eating and the love of offspring, and of these two the former is undoubtedly the stronger; but, as bearing on our subject, it is interesting to note that where little or no exertion is necessary to procure sufficient food, just as where a supply large enough for ordinary wants cannot be obtained even with great exertion, the human race is of an inferior kind. It attains its maximum development where food is plentiful, but where it is necessary to work hard for it. Neither the negro, who can obtain a livelihood with scarcely any trouble, nor the Esquimaux, who can hardly procure one at all, can be compared in bodily or mental vigour with the European or the stalwart American settler.

But in many occupations under our system of civilised or divided labour, certain parts of the body are called into play to the exclusion of others; and it should be the special function of gymnastics to remedy this tendency to unequal development. No one who, especially in our large towns, has had occasion to examine the chests of a number of individuals—a process the necessity for which in our hospitals is painfully frequent—can have failed to be struck with the multitude of badly formed busts and undeveloped bodies which come before him. Now, for these, in many instances, a process of physical education would be their salvation. Unfortunately it is not always to be had, for *skilled* masters in this department are much rarer than in those which relate to mental growth.

Then, again, with reference to another and perhaps a more interesting matter still, mammas constantly complain of the difficulty they have in getting their darlings to sit upright when they come to the age of fifteen or sixteen. Only the other day we were asked what should be done with a young lady who would not sit upright: our reply was unhesitating—"Let her have a course of light gymnastics." Some of our fair readers may remember their sufferings under the old system—not altogether, we are afraid, banished even now—of back-boards; and bearing in mind their hours of penance in them, they may desire to avert such troubles from their daughters: to these also we say, "Substitute gymnastics." Growth at the period of life of which we speak is remarkably rapid both in boys and girls; they shoot up and become tall and lanky, they want filling out, and are troubled with growing pains. Even men, when tall and thin, are seldom very erect, their muscles are too weak; and there is only one way of overcoming this weakness—by exercising them. Strengthen the muscles, and the drooping shoulders and semi-erect gait will disappear.

Muscles are intended for interrupted, not continuous action; give them intervals of rest, and they will go on acting, we had almost said for ever. But, it may be objected, there is the heart, which you have told us is really a hollow muscle; were it to cease to act, we should die. No doubt this is true in one sense: were it permanently to cease to act, undoubtedly we should die, but it is not continually contracting, it alternately contracts and expands, action and repose succeed each other even in the case of the heart, and still more should this be so with other muscles. To place a child upright against a straight board, or even on a music-stool, without any support, is not to give the muscles free play, but rather to confine their effect to a rigid and unyielding fixation of the body. Here it is all action and no repose for certain muscles, all repose and no action for others, and this is the very thing to be avoided; uniform development, the result of uniform exertion, is that at which we should aim.

One of the most serious features of life in the present age, is the rate at which men of action live in the great crowds which constitute our modern cities. The numerous inventions which have enabled us to vanquish time and space, have entailed on us the necessity of living fast, to use the word in its plain sense. He that would win the race of life must be at least as speedy as his fellow competitors. So much depends now-a-days on education, both general and special, that parents are encouraged to force, as it were, the intellects of their children. A boy that is fond of his books is favoured over his rougher and hardier fellows, who prefer exercise in the open air to study: perhaps in our modern civilisation this is natural, but there can be no doubt that when carried to any great extent it is prejudicial. For a man to fight well the battle of life, nothing is more essential than a sound mind in a healthy body, but to insure a healthy body nothing is more needful than a due indulgence in the healthy sports of childhood, a due proportion of bodily, as contra-distinguished from mental, exertion in boyhood and manhood. The fine physique of our nation is no doubt to some extent due to our partiality for outdoor sports, and doubtless also the effect reacts on the cause. All this only serves to illustrate our thesis, which is that education of the body is as necessary as education of the mind, and that the powers of the one should be cultivated alike with the powers of the other.

For all of these purposes gymnastics is the instrument we would employ; not gymnastics in the sense of such exploits as those of Blondin, Leotard, and the thousand-and-one nameless performers who alternately delight and horrify their eye-witnesses—we cannot call them audiences—but gymnastics in the sense of a system of physical education. Now it is quite clear that the exercises which would be calculated to fit a strong and hardy man for the Oxford and Cambridge boat race, would be altogether unsuited for a gentle and tender girl who had a tendency to stoop. Hence it is good to speak of light and heavy gymnastics, the former adapted for the weaker class of learners, the other for those of stronger frames and more mature years. Further, we may classify gymnastic apparatus into movable and fixed; and we may deal with exercises specially intended to develop the upper parts of the body, and exercises specially intended to develop the lower limbs, as well as those which affect both.

As already pointed out, every judicious series of exercises will imply a training of the organs of respiration and circulation. Walking and running are those which perhaps most readily effect this, as they do not interfere with the upper limbs, and hence they are chiefly employed for improving "the wind" as it is called, for when the arms are brought into play for any powerful effort, say pulling at or lifting a heavy weight, if there be great resistance, the on-looker will speedily observe the performer become redder and redder in the face, till he is almost purple. The reason of this is that, the muscles of his arms having proved insufficient to effect the removal of the body causing the resistance, he has called a new set of muscles into play by fixing his chest, so that during these powerful efforts no breath can be taken. Consequently, as the blood is rapidly undergoing change in the rigid and contracted muscles, and as the heart continues to drive the blood thus fouled through all parts of the body, it not being aërated by passing through the closed lung, the surface darkens, and the blood which should pass through the lung accumulates outside it, the two together producing the reddening and darkening of the features. This is straining the lung, not exercising it: it is equally injurious to both lungs and heart, for both are alike strained, the lungs to resist, the heart to drive on, the blood current. Hence, for gymnastics of the lungs and heart, exercises which do not involve the upper limbs should be selected.

It has been suggested that to exercise the lungs, that is to say to train them, the playing upon wind instruments might be usefully employed. Now, the playing upon such instruments as the flute and flageolet requires, comparatively speaking, little effort compared with that necessary in playing the more powerful brass instruments; and, provided the former be not used in excess, would have, to say the least of it, no prejudicial effect on the lungs. This is not so with the others of which we have spoken. Only the other day, a bandsman came before us, pale and wasted. One would have supposed, to look at him, that he was consumptive. On examining his chest, however, it was soon found that it was not his lungs, but his heart, which was affected. He was suffering from one of the worst forms of heart disease, such as is generally induced by too great a strain on the organs of circulation, and which in his case led to speedy death. In this instance there could be absolutely no other cause traced than the nature of his employment.

The reason one set of instruments might be used in the way hinted at, and not another, may be readily explained. The essential part of the exercise in blowing wind instruments consists in a sudden and complete dilation of the lung with air, and its subsequent ejection, more or less forcibly and more or less gradually, the lung acting like the bag in the bagpipe. The complete distension of the lung is, as a rule, a good thing; but when great force is employed to empty it, when the escape of the air is resisted in any way, the proper and equable flow of the blood through the body, and especially through the lung, is prevented. Hence it is that in players on large brass instruments the face is congested and red during their exertions; hence also results the injury to the heart, with sometimes, it may be added, destruction of certain portions of the lung. Thus, to exercise the lungs aright we should aim at their full distension, but at the same time at a free expulsion of the respired air; and there is no better method of insuring this than exercise on foot, walking or running as the case may be.

To one entering a modern gymnasium for the first time, the scene irresistibly appeals to his imagination as a representation of some mediæval place of torture. The spars, the ropes, and the restless figures swinging to and fro give the place a character quite peculiar to itself. Now, the exercises employed as a means of training in these establishments are mostly of two kinds; in one the body is the fixed point, in the other it is the movable portion of the apparatus. Certain also of the exercises are intended to develop the upper limbs, certain others the lower, but the former are the more numerous and important. It is further to be remarked that a great many of our sports and pastimes tend to develop one side or portion of the body more than another, a thing which should, if possible, be avoided, equable development being most desirable. Thus football favours the growth of the lower limbs; cricket, the lower limbs and right arm;

rowing, the lower limbs, loins, and arms; racquets, tennis, etc., chiefly the lower limbs; fencing, the lower limbs and right arm; walking, running, leaping, etc., the lower limbs only. To counteract the influence of these, or perhaps, more exactly, to correct it, is the function of the teacher of gymnastics; and it is for this reason, perhaps, that most gymnastic exercises tell largely on the arms.

We have already pointed out that movement is the great thing in all exercises. To overcome resistance as well as to secure motion, no doubt, implies the expenditure of more force; but mere movement is in many cases a gain real and decided. Athletes will boast of the size of their biceps (the large muscle which stands prominently out when the arm is bent at the elbow, so as to bring the fist to the shoulder), and of the weight of the dumb-bells they can use; but the wise man will think less of these things than of the fact that his muscles are getting that exercise which is essential to their well-being and to his healthy condition. What we chiefly insist on is, that motion is of more importance than is violent exercise, and hence that light apparatus may be quite as efficacious as heavier implements.

An American, called Dio Lewis, has issued a work and a series of apparatus which will be found useful in the physical training of boys, girls, or invalids. The apparatus is contained in a small box, and consists of a pair of light wooden dumb-bells, a pair of very light Indian clubs, a long wooden rod, and a pair of wooden rings, the last for combined exercises. In Mr Maclaren's system, dumb-bells are alone recognised, all the more difficult exercises being accomplished by means of fixed apparatus. What are called gymnasiums are sometimes advertised in the papers: these usually consist of a number of cords, composed of India-rubber, which the individual desirous of exercising himself is supposed to pull out, the elasticity of the rubber causing the recoil. This is all very well; but the apparatus is expensive, and, it must be added, unsatisfactory, except for exercising certain definite groups of muscles under the direction of a surgeon. Nothing more is wanted than what we have mentioned (light dumb-bells, light Indian clubs, and a rod); and, indeed, it may be said that the motion of the body itself, without any extra artificial resistance like that afforded by dumb-bells, Indian clubs, and such like, is quite sufficient for the purposes of physical education.

There is with few exceptions a tendency for the right side to attain a superiority over the left. It is advisable in certain respects to counteract this tendency. Hence exercises in physical education should take cognisance of one side as well as of the other. There are, however, certain cases where this should not be so; but these come more under the notice of the medical man. They are cases of deformity or partial paralysis.

Many kinds of mal-development are best treated by gymnastics. Take for instance what is called the *pigeon breast.* In this the breast-bone of the individual projects far forwards and forms a ridge like that of a fowl; his ribs are flattened and too straight, running almost directly backwards. The chest, which contains the lungs and heart, is therefore too narrow from side to side, too wide from back to front; but the latter does not compensate for the former. Such individuals are always unhealthy. They are liable to coughs and colds, and very frequently are consumptive. Had they when young, before the bones were too firmly set and knit together, been put through a regular series of exercises which would tend to expand the chest, this would have been avoided, and the individuals might have been strong and healthy. In no case is it too late to do something, provided only the exercises be judicious; for this, after all, is the main point. They should be regularly graduated, becoming more and more active till something of the desired result has been attained.

Others, again, suffer from a peculiarity the very reverse of that just alluded to; their breast-bones, instead of projecting or bulging, retreat and form a hollow at their lower portions. This condition is frequently observed in shoe-makers who have taken to their trade early in life, and whose health has not been satisfactory. Many of these operatives work with the boot or shoe constantly pressing on the lower part of the breast-bone, so that if the bone is soft, as it is in certain forms of disease, or indeed we might say as it is in all unhealthly conditions early in life, a permanent indentation is the result. In such conditions also gymnastics is the appropriate remedy.

Nor does the application of exercise to medicine cease here. Ling, an enthusiastic Swede, conceived that gymnastics might be much more widely used than they even now are in the treatment of diseased conditions, especially of deformities. He was, in course of time, able to erect a building devoted to this purpose, and even now this institution and many others on the Continent are engaged in the work of healing.

There is no deformity more painful to the sufferer or to the beholder than a crooked spine. But of this there are two kinds. In one the bones are thrust abruptly backwards, so as to form a projecting angle; and, as this generally depends on disease of the bone, little is to be done for it. In the other the spine is curved, but not angular, and the curve is to one side, not backwards. One shoulder is higher than the other, and the sufferer has what is called a hunch-back. This may also to some extent depend on diseased bone, but it is certainly favoured by weak muscles. Exercise, therefore, which will tend at once to straighten the spine and to strengthen its supporting muscles, should be encouraged; that is, if there is nothing to indicate thas its employment might cause mischief. Thus, were the bones in a state of actual and active disease, rest should be urged; but if there is nothing more than a mere softness of their texture, exercise is the best remedial measure possible. It has been too much the practice to bolster up such unfortunates in iron cases of all kinds, what are called spinal supports among the number, and in certain conditions these are, no doubt, requisite; but we strongly insist on the fact that in particular instances they are as injurious as exercise would be in others.

Let us take another illustration. Painters, who have much to do with white lead, are extremely liable, after a time, to what is called lead-poisoning. The lead by degrees gets into their system, and gradually their health deteriorates. They become subject to colicky pains, their bowels are confined, and finally, if they have not taken warning, they have "dropped wrist." The dropped wrist depends on a partial paralysis, a palsy which affects certain muscles, and certain muscles only. The patient may be unable to lift up his hand, so that the back of it shall be turned upwards; yet he may have perfect power to close his fist and to grasp any body with nearly his usual force. In short, the extensor muscles of his hand are paralysed. The same thing, or something similar to it, may occur to other muscles without evidence of any kind of poisoning, so that we may consider the two kinds of paralysis together, putting aside for a moment the treatment that should be adopted to expel the lead from the system.

As a rule, wherever there is partial paralysis, exercise is the thing to do good. But how, it will be said, is it possible to exercise a paralysed muscle, one over which you have no control, no power to make it do as you like? So it may be; still exercise is what is wanted, and it is obtained by means of electricity or galvanism. A galvanic battery, or a magneto-electric machine which you turn with your hand, is employed. The patient's affected hand grasps one of the holders, or, as they are technically called, poles of the battery. The physician applies the other to the affected muscles. If these be very bad, there may be no response to the applied agency, but generally contraction is prompt, and not unfrequently painful. The process is repeated again and again. In other words, the muscle is exercised. Its contraction implies waste, change in its textures, renewal, and growth. The only difference has been that, whereas in ordinary muscular action the nerve stimulus is enough, we have here to apply a galvanic battery to insure the contraction of the muscle; but the result is the same, and in both instances it is beneficial.

We might give other illustrations of the same rule, that growth and health are everywhere dependent on exercise, natural or artificial; but we have said enough to establish our thesis, and, we trust, to attract more general attention to an all-important matter. We are no advocates of violent exertion of any kind, for this, as we have shown, is only too fatal to heart and lungs; but we would strongly urge on parents, especially on those whose children are somewhat weakly, the necessity of physical education. Children who have no desire for the sports of their time of life ought not to be encouraged in their sedentary habits without some counterbalancing means of exercise. It is not good to heavily task either mind or body before they be properly developed. Children should not be tired out either with lessons or with gymnastics, but they should have something of both. Finally, we have shown how exercise, natural or artificial, may be employed in the art of healing for the relief of weakness or even of actual suffering.

The whole subject is so extensive that we have only been able to give a brief outline of it; but we repeat that systematic exercise is an all-important and too much neglected means of maintaining health and of remedying disease.

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